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USING THE LOGISTICS ASSESSMENT
METHODOLOGY PROTOTYPE MODEL
FOR EDUCATION IN
ACQUISITION LOGISTICS

THESIS

Dennis N. Malott
Captain, USAF

AFIT/GLM/LSM/88S-43

DEPARTMENT OF THE AIR FORCE
AIR UNIVERSITY

AIR FORCE INSTITUTE OF TECHNOLOGY

Wright-Patterson Air Force Base, Ohio

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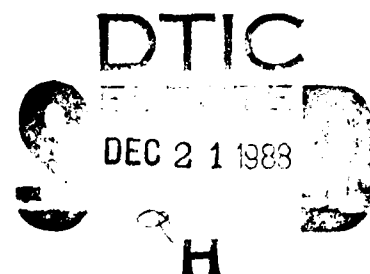
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AFIT/GLM/LSM/88S-43

USING THE LOGISTICS ASSESSMENT METHODOLOGY
PROTOTYPE MODEL FOR EDUCATION
IN ACQUISITION LOGISTICS

Thesis

Presented to the Faculty of the School of Systems and Logistics
of the Air Force Institute of Technology

Air University

In Partial Fulfillment of the
Requirements for the Degree of
Master of Science in Logistics Management

Dennis N. Malott, B.S., M.P.A.

Captain, USAF

September 1988

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Preface

The current emphasis on reliability and maintainability has resulted in the development of several computer aided management tools. The Logistics Assessment Work Station was developed under the Logistics Assessment Methodology Prototype Program and is a computer aided tool for acquisition managers. The purpose of this study was to develop a training package to provide students in acquisition logistics the opportunity to use this methodology to assess the logistics supportability of new or existing equipment.

I would like to express my thanks to Mr. Mike Silverman (AFWAL/FIX), Lt. Col. Robert Materna (AFIT/LSM), and Mr. Kevin Deal and Mr. Les Spangler (Dynamics Research Corporation) whose guidance and encouragement made this all possible.

Dennis N. Malott



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List of Acronyms

AGREE: Advisory Group on Reliability of Elect. Equip.
AFIT: Air Force Institute of Technology
AFLC: Air Force Logistics Command
AFR: Air Force Regulation
AFSC: Air Force Specialty Code
AFWAL: Air Force Wright Aeronautical Laboratories
ASD: Aeronautical Systems Division
ATF: Advanced Tactical Fighter
CALs: Computer Aided Logistics
CALS: Computer Aided Logistics Support
CAMS: Core Automated Maintenance System
CDS: F-16 Centralized Data System
DOD: Department of Defense
DPML: Deputy Program Manager for Logistics
DRC: Dynamics Research Corporation
IBM/PC: International Business Machines/Personal Computer
ILS: Integrated Logistics Support
ILSP: Integrated Logistics Support Plan
ILTO: Integrated Logistics Technology Office
LAMP: Logistics Assessment Methodology Program
LAWS: Logistics Assessment Work Station
LOGTIES: Logistics Technology Insertion for Existing Systems
LRU: Line-Replaceable Unit
LSA: Logistics Support Analysis
MDC: Maintenance Data Collection
MS-DOS: Microsoft Data Operating System
MTBF: Mean Time Between Failure
MTBM: Mean Time Between Maintenance
OMB: Office of Management and Budget
PACAF: Pacific Air Forces
PC: Personal Computer
PCE: Professional Continuing Education
POMs: Program Objective Memorandums
REMIS: Reliability and Maintainability Information System
R&M: Reliability and Maintainability
SPOs: System Program Offices
SRFCS: Self-Repairing Flight Control System
TAF: Tactical Air Forces
TICARRS: Tactical Interim CAMS and REMIS Reporting System
URR: Ultra-Reliable Radar
USAF: United States Air Force
USAFE: United States Air Forces, Europe
VHSIC: Very High-Speed Integrated Circuitry
WPAFB: Wright-Patterson Air Force Base, Ohio
WSMIS: Weapon System Management Information System
WSMP: Weapon System Master Plan
WSRK: War Reserve Spares Kit

Abstract

The current emphasis on reliability and maintainability has resulted in the development of several computer aided management tools. The Logistics Assessment Work Station was developed under the Logistics Assessment Methodology Prototype Program and is a computer aided tool for acquisition managers. The purpose of this study was to develop a training package to provide students in acquisition logistics the opportunity to use this methodology to assess the logistics supportability of new or existing equipment.

A 5.25 inch diskette and a flow chart of procedures are included to provide students the needed information to allow them to accomplish a sensitivity analysis of a black box assembly under procurement consideration. Step-by-step instructions demonstrate the ease of use and the power contained in the LAWS algorithms to allow the user to accomplish an in-depth supportability analysis.

Overall, the training package enhances the quality and depth of the acquisition logistics education by exposing the student to a real world management tool which, if used properly, can make their job both faster and easier. LAWS software is a promising tool for logistics supportability analysis of both existing and new equipment items.

USING THE LOGISTICS ASSESSMENT METHODOLOGY
PROTOTYPE MODEL FOR EDUCATION
IN ACQUISITION LOGISTICS

I. Introduction

General Issue

This paper describes the process and procedures used to develop a computer aided instruction and educational package to assist acquisition logistics students to become more familiar with the Logistics Assessment Work Station (LAWS) software developed under the auspices of the Logistics Assessment Methodology Program (LAMP). Proper use of the LAWS software will make their job as future managers in the acquisition process, both faster and easier.

During the conceptual phase of the acquisition process, many trade-offs must be considered involving cost and performance characteristics of a weapon system. The urgency to get a completed item into the field for operational use has a significant impact on the schedule of acquisition events. Traditionally, the transition from the conceptual phase through the demonstration and validation phase to full scale development phase has not provided sufficient time to perform a thorough evaluation of all of the aspects of design alternatives and their

possible impact on logistics supportability.

By the time a developmental item has begun its initial operational test and evaluation, many of the characteristics which have a diminishing impact on the supportability of the system have been incorporated into the system. Elimination or modification to the system after the design is complete can often be cost prohibitive. Without the aid of sophisticated computer software algorithms, it is extremely difficult to design and develop a new weapon system that attempts to minimize the supportability impact associated with the ten integrated logistics support (ILS) elements. With the introduction of the Air Force Reliability and Maintainability (R&M 2000) Program, Air Force policy now requires all planning to address the five goals of the R&M 2000 Program (8).

In 1982, under government contract, the Dynamics Research Corporation (DRC) began development of the LAWS computer program under the auspices of the LAMP program to assist system program managers to assess various logistics supportability issues of both new and improved weapon system procurements. LAWS design allows sensitivity analysis to be accomplished to determine system compliance with Air Force R&M 2000 goals: increase combat capability, increase system survivability, decrease

manpower requirements, decrease cost and quantity associated with mobility requirements, and decrease the total life-cycle cost of the system (8:1).

The purpose of this study is to develop an educational scenario in the form a simulated procurement decision problem for use by future students of acquisition logistics in the Air Force Institute of Technology (AFIT). Students may be provided the opportunity to have some 'hands-on' experience in using the LAWS software. If used properly, the training scenario of LAWS will illustrate the systems relationship between design decisions and logistics supportability issues throughout the life-cycle of the system. The exercise displays how the use of LAWS enables decision makers to assess the impact of changes on the fulfillment of the five R&M 2000 goals, and the impact on the overall supportability of the system.

Problem Statement

A significant portion of acquisition managers today and the majority of students of acquisition logistics complete their formal and informal education and training without ever having the opportunity of actually using any of the Computer Aided Design/Computer Aided Logistics (CAD/CALs) software that is in the process of being developed and implemented throughout the industry and the USAF.

To meet this growing need in the academic arena, the purpose of this effort was to develop and present an educational package designed to allow students to manipulate design and performance data and interpret the results. Although many 'real world' problems can be applied to this exercise for user interpretation, the educational scenario presented here involved the use of a representative black box which required no technical knowledge of its specific functions in order to accomplish the analysis. Students were asked to select alternative design options and accomplish a LAWS analysis to derive an optimum solution to satisfy the five R&M 2000 goals. Specific goals of the research problem were: to enhance the student understanding of the systems relationship between design decisions and logistics supportability issues throughout the life-cycle of the system, and to make the students aware that the proper application of computer aided tools can save both time and money in evaluating alternative logistics supportability issues.

Background

In response to decreasing manpower and budget allocations in the Department of Defense (DOD), there has been increased emphasis on using computers throughout the design, construction, procurement, and support of DOD

weapon systems. According to a USAF publication on the R&M Process published in October 1987, the benefits of using computer-aided tools include the following: a 15 to 30 percent reduction in engineering and design cost; a 30 to 60 percent reduction in the overall lead time; a 200 to 500 percent increased product quality or yield; a 300 to 3500 percent increased capability of engineers; a 40 to 70 percent increase in the production facility output; a 200 to 300 percent increase in the up-time of capital equipment; a 30 to 60 percent decrease in the amount of work-in-process; and a 5 to 20 percent reduction in personnel costs (9:83).

DRC developed the LAWS computer software under government contract to assist program managers in assessing weapon system procurements. The algorithms of LAWS are used to assess the logistical impact of each ILS component and to conduct sensitivity analysis of the system design impact on the R&M 2000 goals. Furthermore, applications of LAWS software to enhance reliability and maintainability of existing USAF hardware is being implemented under the auspices of the Logistics Technology Initiatives for Existing Systems (LOGTIES) program (18).

The LOGTIES Program is reliant on, and accomplished in cooperation with, several DOD systems including the existing unclassified portion of the data base of the

Weapon System Management Information System (WSMIS).

WSMIS was developed to provide an audit trail and limiting factor data on the reliability and maintainability of problem parts for fielded weapon systems (18, 14:8).

Other data collection systems used in LOGTIES include:

Core Automated Maintenance System (CAMS), Reliability and Maintainability Information System (REMIS), Tactical Interim CAMS and REMIS Reporting System (TICARRS G333), and the Maintenance Data Collection System (MDC).

Objectives of the LOGTIES Program are to provide a bridge between the Air Force Wright Aeronautical Laboratory (AFWAL) and the Air Force Logistics Command (AFLC) for developing and sharing supportability information, to use models and methodology approved by DOD to meet user information and analysis requirements, and to provide quantified R&M 2000 analysis results, reports of findings, and prioritized options to the implementing command (14:7).

Research Purpose

The purpose of the research was to develop an educational package for the use of LAWS software in an academic setting. This package includes a 5.25 inch computer diskette which (on command) inputs modified LAWS data files into the existing computer data files in the LAWS subdirectory, thus allowing students to accomplish

the exercise. When completed, the experience of revising and interpreting the computer data files will enhance the students' understanding of the interrelationships between the ten ILS elements logistics supportability issues and their impact on the five R&M 2000 goals. Exposure to the LAMP/LAWS methodology enhances the quality of acquisition logistics students' education.

Research Design

Maintenance data on the F-16C aircraft was used as a baseline for the simulation because of the availability of accurate F-16 maintenance data from the TICARRS G333 data system. Fictitious design and performance characteristics for a black box are input into the LAWS program for students to accomplish a logistical sensitivity analysis. The sensitivity analysis provides data on alternatives in the design to enhance the new system supportability and maintainability throughout the intended life-cycle of the system.

The sequence of events accomplished during the research is listed below:

- (1) Version 1.2 of the LAWS program and appropriate manuals were obtained from DRC.

- (2) Available maintenance and design data on the F-16 aircraft were input into LAWS for use as a baseline to construct a black box design.

(3) Representative, but fictitious design specifications, support requirements and reliability and performance characteristics were input into the LAWS program under specific support scenarios and provided in a problematic format for analysis.

(4) The specific problem was designed to require a choice between three design alternatives; existing, new, and improved versions of a black box. The possible choices of design alternatives will be discussed later in Chapter IV.

(5) A problem scenario was presented in a "read.me" text file (Appendix A) which proposed a simple analysis of the data to assess system compliance with the R&M 2000 goals.

(6) Using the information provided to the student, LAWS can then be used to accomplish sensitivity analyses to provide data on the acceptable design alternatives.

(7) Students can then use LAWS outputs to determine which possible design allows for the most cost effective operation and allows the system to obtain its maximum sortie generation capability and operate at peak performance.

The data files were input into the LAWS program and analyzed according to the ten separate ILS elements listed below. The ten ILS elements include: maintenance

planning; manpower and personnel; supply support; support equipment; computer resources; facilities; technical data; training requirements; design interface; and packaging, handling, and transportation as discussed in AFR 800-8, Attachment 3 (7).

Scope and Limitations.

Scope. The LAWS program is an International Business Machines/Personal Computer (IBM/PC) based software package which is designed to be operated on a computer system with a minimum of 10 megabyte hard drive and a minimum of 640,000 (640K) available random access memory.

This study entailed the use of the LAWS software package to accomplish a thorough analysis of a black box in the design stages of development. Acquisition Logistics students can be provided with LAWS data files on 5.25 inch diskettes to accomplish logistics support analysis.

Because of the accuracy of the F-16 TICARRS system, maintenance data from the F-16C aircraft was used as a baseline for the LAWS analysis.

Limitations. The LAWS software has some inherent limitations due to the convenience of being IBM/PC compatible. One constraint with version 1.2 of the LAWS software is the limitation to process no more than ten

line replaceable units (LRUs) at a time during each set of data files (12). Three separate sets of data files, one for each design alternative, are required for the accomplishment of this analysis.

Future versions of the LAWS software are projected to include a Dynametric model that will possess the increased capacity to process numbers of LRUs approaching 1000 (19).

Because of the limited duration of the study and the attempt to make this problem one that can be solved by students inexperienced in LAWS usage, the flow diagram (Appendix B) accompanying the scenario includes an example of a sensitivity analysis.

The analysis entails use of the black box in a simulated Tactical Air Forces (TAF) scenario. The TAF scenario includes both training operations and war-time operations for Pacific Air Command Air Forces (PACAF) and United States Air Forces Europe (USAFE).

Although this study focused on performing a supportability assessment of a black box in the TAF environment, this methodology could be applied to virtually any piece of equipment in any environment in which the Air Force operates.

Terminology

There are several terms used throughout the thesis

which have particular meanings within the context of this paper. Definitions of terms are listed below:

Integrated logistics support (ILS): interactive process to provide initial planning and funding to insure that the user receives a system that will meet performance requirements. A major objective of ILS is to insure that the ten elements of ILS are integrated into a logistics management plan, hereafter referred to as the ILS plan (ILSP) (1:11).

Integrated logistics support elements: the ten elements that make up the ILS elements including the following: maintenance planning; supply support; test and support equipment; transportation, packaging, storage and handling; personnel; training; facilities; technical data; computer resources; and design interface (1:351).

Life-cycle cost: the cost to operate a system for the entire time period of its existence. The life-cycle is separated into four phases. The four phases include the following: (1) research and development cost (design, develop, fabricate, test and evaluate); (2) production and construction cost; (3) operation and maintenance cost; (4) system retirement and phaseout cost (1:19).

Line Replaceable Unit (LRU): a subcomponent of a larger end-item which is removed and replaced to maintain the system in serviceable condition. LRUs are also known

as parts.

Logistics Assessment Work Station (LAWS): the computer software station designed to support the Logistics Assessment Methodology Prototype (LAMP) on a personal computer microsoft data operating system (PC MS-DOS) computer with a minimum of 640K RAM and a minimum 10 megabyte hard drive (12).

Logistics Assessment Methodology Prototype (LAMP): a computer model designed to provide a tailored Logistic Supportability Analysis to quantitatively assess supportability characteristics of the system to which it was applied (12:2-8).

Logistics Support Analysis (LSA): the analytical process used to identify and evaluate logistical support requirements for a system. It is a tool used throughout the early stages of development to "evaluate maintenance analysis, life-cycle cost analysis, and logistics modeling" (1:12).

Maintainability: the measure of the ability of an item to be retained in or restored to specified condition when maintenance is performed by personnel having specified skill levels, using prescribed procedures and resources, at each prescribed level of maintenance and repair (4:5).

Maintenance: the required actions necessary to keep

the system operational. Maintenance involves the actions necessary to "retain a product in, or restore it to, serviceable condition" (1:17).

Maintenance concept: defines criteria covering maintenance levels, major maintenance functions accomplished at each level, base support policies, effectiveness factors, and primary logistics support requirements for a system. It is the measure used to perform the LSA (1:18).

Reliability: the probability that an item can perform its intended function for a specified time interval under prescribed operational conditions" (4:8).

System: a "nucleus of elements (equipment, facilities, material, software, data, services, and personnel) required to operate and support a self-sufficient entity in its intended operational environment throughout its planned life-cycle" (1:1).

The concepts presented in this chapter were developed and expanded upon through an extensive literature review and through the personal contacts with experts on the different items being discussed. A more thorough development of these concepts is presented in Chapter II of this report.

II. Literature and Source Review

This chapter includes information from both published and unpublished sources and addresses some of the steps required during the acquisition process. Additionally, this discussion encompassed current DOD policies and how the LAMP methodology is being applied to enhance the acquisition process. This section is broken down into several subsections to address each of these items.

Introduction

Logistics is viewed as the composite of considerations necessary to assure the effective and economical support of a system throughout its programmed life-cycle (1:9). Accordingly, appropriate logistic support requirements must be clearly established in the early stages of concept development and system design.

Effective system design is a process of going through steps to transform an expressed operational need into a set of specific performance parameters through an interactive process of functional analysis, synthesis, optimization, definition, design, test and evaluation (1:9). Effective design requires that the completed system be reliable, dependable, available, and maintainable.

Reliability and Maintainability (R&M)

Reliability. Reliability is defined as 'the probability that a system or product will perform in a satisfactory manner for a given period of time when used under specified operating conditions' (1:12). In the quest to develop a reliable system, designers are often required to place redundant parts into the system to insure that the system will function as designed when it is required. Redundancy of the system components complicates logistics supportability issues by requiring additional spare parts and increased maintenance actions.

Numerous reliability models have been developed to aid in the evaluation of design alternatives, some of which will be discussed later. Ultimately, the design engineers must establish an acceptable failure rate for the system and choose the most reliable and most cost effective components that provide for a cost effective mix of reliability and supportability.

Maintainability. Reliability and maintainability (R&M) are very closely related and must be compatible and mutually supportive. Design engineers must consider the effect of corrective and preventive maintenance in degrading the total system reliability.

Maintainability is an inherent design characteristic dealing with the ease, accuracy, safety, and economy in the performance of maintenance functions (1:15). Elapsed

times, personnel labor-hour rates, maintenance frequencies, and maintenance costs are the measurements used to assess system maintainability.

The maintenance frequency factor, Mean Time Between Maintenance (MTBM), is a major parameter in determining the system availability and overall effectiveness (1:13).

The emphasis on reliability and maintainability has experienced significant changes over the past thirty-five years. The purpose of the next section will be to cover some of the predominant changes.

Evolution of R&M Awareness

Historically, prominent emphasis in the acquisition process has been on the cost, performance, and schedule. Reliability and maintainability were given considerably less emphasis in the acquisition process (17:122).

The emphasis on cost, performance, and schedule provided for the national defense of our country and has sustained our Armed Forces to date. However, as stated by General Russ in his May 1985 article printed in Air Force Magazine "the price we have paid for manpower and training, for spare parts, for support equipment, for out-of-commission rates, and for mobility restraints is too high and can no longer be allowed to continue" (17:125).

In the early 1950's, the major emphasis of reliability was to keep the piece of machinery working. The Advisory Group on Reliability of Electronic Equipment (AGREE) was established under the Office of the Secretary of Defense on August 21, 1952, to 'monitor and stimulate interest in reliability matters and recommend measures which would result in more reliable electronic equipment' (16:15). Electronic equipment was only the first step. Interest in reliability soon spread to other areas of acquisition.

In the 1960's, the emphasis shifted towards mission accomplishment. The change in emphasis in reliability has been brought about by the 'success, or lack of success' in defense programs where reliability was a significant concern (16:15).

In the mid 1970's, emphasis was given to the costs associated with operation and support of the equipment, and to the environmental aspects of realistic operational testing (16:15). Life-cycle costs became a bigger issue along with greater emphasis on the item being tested in its intended operational environment.

On April 5, 1976, the Office of Management and Budget (OMB) published Circular A-109; addressing major system acquisitions. With the premise that the acquisition of a major weapon system by the government is one of the most 'expensive activities performed to meet

national needs," the circular laid the groundwork for significant acquisition reform. The first item included under management objectives is cited below:

Ensure that each major system: Fulfills a mission need. Operates effectively in its intended environment. Demonstrates a level of performance and reliability that justifies the allocation of the Nation's limited resources for its acquisition and ownership [3:2].

Although the major items of reform were directed at acquisition strategies of dual sources, the OMB stand on reliability was clear.

A 29 March 1982 memorandum for the Defense Resources Board concerned the revision of DOD Regulation 5000.1, Major Systems Acquisition, and referenced Circular A-109. Under the category of management principles and objectives, the first item of the memorandum called for "defense systems that are cost-effective and ... responsive to mission needs." The second item proclaimed that "improved readiness and sustainability are primary objectives ..." (6:3).

"Today the emphasis is on readiness," and on having the least expensive system to support, and on availability of adequate manpower and skills (16:14).

Part of the shift in interest of manpower is the fact that we cannot expect to receive large increases in manning authorizations. "Even if we [USAF] had the congressional authorizations and could afford the price

for training and salaries, there is no assurance that larger numbers of high-quality people will be available" (17:122).

One of the major advantages of increased reliability is the impact it has on driving down the life-cycle cost because of reduced quantities of spare parts. In 1985, the USAF managed an estimated 835,000 different types of spare parts worth about \$38 billion (17:123).

The most significant advantage to improved system maintainability is that the mission-capable rate of the system is increased. If the system can be designed to "ease troubleshooting and repair, more sorties can be generated" (17:123).

The end-result is that now system program offices (SPOs) have to demand more and more in the acquisition process. Copious amounts of comprehensive logistics planning must be accomplished "up-front" in order to still have a reliable, supportable, and maintainable system twenty years from now.

R&M 2000

The DOD continues to place greater emphasis on the subject of reliability and maintainability. On 1 October 1986, the USAF published the Air Force Reliability and Maintainability Policy in the form of a regulation: AFR 800-18. The purpose of the AFR 800-18 was to "implement

DOD Directive 5000.40, 8 July 1980, and the Air Force R&M Action Plan, R&M 2000, 1 February 1985* (8:1).

The goals of the regulation are listed below in order of priority:

Increase Combat Capability. Increase operational capability, sustainability, suitability, and probability of mission success by acquiring systems that break infrequently and are easily and quickly repaired.

Increase Survivability. Increase the survivability of the combat support structure. Reduce or eliminate elements of maintenance and support structure subject to attack or destruction, and improve the ability of the unit to disperse for survivable operations.

Decrease Mobility. Decrease mobility requirements per unit. Reduce or eliminate airlift requirements for deploying units, and support requirements for ground mobile units.

Decrease Manpower. Decrease manpower requirements per unit of output. Ensure that systems can be operated and maintained with minimum personnel, specialties, and skill levels.

Decrease Costs. Decrease R&M-driven costs [8:1].

In order to accomplish the intended mission, many operations rely completely on having the required support equipment when and where it is needed. Additionally, system downtime is based on availability of test equipment and spare parts. Other items requiring consideration include special tools, ground handling equipment, maintenance stands, and facilities. The logistics support items required for the system are addressed and evaluated under the major heading of the LSA.

Logistics Support Analysis (LSA)

The rationale for the implementation of the LSA process is to insure that the military services accomplish the actions necessary to insure that the following objectives are met:

- (a) cause supportability requirements to be an integral part of system requirements and design,
- (b) define support requirements that are optimally related to the design and to each other,
- (c) define the required support during the operational phase, and
- (d) prepare attendant data products [5:iii].

LSA is a tool that 'constitutes the integration and the application of various techniques and functions to insure that supportability requirements are considered in the system design process' (1:140).

The objectives of the process include establishment of supportability requirements, evaluation of system design configurations, evaluation of trade-offs in areas like alternative repair policies and levels of maintenance. Additionally, the LSA will address reliability and maintainability characteristics in the design, determine the use of off-the-shelf equipment, and influence the design to enhance supportability through the appropriate selection of system components and responsive suppliers (1:140-142).

All of the elements listed above have an impact on

the provisioning and acquisition for the system. Accordingly, all of the 10 ILS elements have an associated cost. The life-cycle cost of the system depends on the decisions made in the early part of the program when the determination is made to make an item reliable, maintainable, and repairable.

Logistics, in one form or another, is an integral part of each of the phases of the life-cycle. One must plan for logistic support, design for system supportability, acquire and distribute the appropriate elements of logistics, and maintain a logistic support capability throughout the planned system life-cycle. One methodology which has evolved in recent years is the use of Computer Aided Logistics Support.

Computer Aided Logistics Support (CALS)

On 19 April 1984, the Assistant Secretary of Defense signed a memorandum "chartering a joint DOD industry ad hoc group under the auspices of the Institute for Defense Analyses to develop a strategy and recommend a master plan for Computer Aided Logistics Support (CALS)" (15:8). The rationale for the memorandum was that DOD had the foresight to realize the possible "digital form" of logistics support products.

The objectives of the CALS program was threefold.

- (1) Design more supportable weapon systems.

(2) Transition weapon system logistics and technical support throughout the system life-cycle from paper-based to digital, near paperless modes.

(3) Routinely create, distribute and use logistics and technical information for new weapon systems in digital form [15:8].

It was already apparent that the emphasis on reliability and maintainability was becoming more and more significant. The focus of research and development was no longer just on the cost, schedule, and performance of the system, but was on reliability and maintainability as well.

Logistics Assessment Methodology Program (LAMP)

To accommodate policy changes in AFR 800-18, two new offices were established in early 1985 at the Air Force Wright Aeronautical Laboratories (AFWAL) to address specific logistics supportability issues. The two offices were collocated and came to be known as Logistics Technology and Logistics Operations, AFWAL/FIX and AFWAL/CDL respectively. The initial charter of the two offices was to manage the supportability tasks of advanced development programs and to ensure that all phases of ongoing programs addressed appropriate logistics supportability tasks (18). AFWAL/CDL embarked on a program to lessen the amount of labor intensive tasks required of a Deputy Program Manager for Logistics (DPML).

The AFWAL/FIX office, Integrated Logistics

Technology Office (ILTO), embarked on a program to integrate information systems and logistics analysis. The end result was the development of the LAMP program which led to the production of LAWS (18). The high utility of LAWS has been demonstrated in numerous case studies, and 'it has generated widespread interest and support among the logistics analysis communities in the DOD and industry' (18).

Logistics Assessment Work Station (LAWS)

LAWS meets the requirements set forth by the Secretary of the Air Force in 1984, and an internal USAF assessment is in progress to determine if the LAWS should be established as one of the 'standard logistics analysis tools' (18).

During the early stages of development, the LAMP methodology was used and tested in a 'quick look' application in seven different situations. These situations involved the use of LAWS in primarily a qualitative role (2). The tests included projects on the Advanced Tactical Fighter, the F-16, and the Strategic Defense Initiative. Some of the specific programs were the Advanced Integrated Avionics, the Very High-Speed Integrated Circuitry (VHSIC) 1750A Computer, the Ultra-Reliable Radar (URR), and the Self Repairing Flight Control System (SRFCS). In each of the cases listed

above, LAMP methodology was used to conduct a 'front-end' logistical analysis for future concepts (18).

Following favorable results from the quick look analysis, the LAWS program was used to investigate supportability issues on three of the programs. These programs included the URR, the VHSIC 1750A, and the SRFCS. The three programs involved the use of LAWS in both a qualitative and a quantitative role (2).

In summary, DRC displayed the ability to apply the LAWS program software to the three programs listed above to 'define a structured methodology for the assessment of supportability related issues within the laboratory environment' (11:5). LAWS successfully enabled the user to compare designs, consider 'what-if' analysis, generate sensitivity curves, display definitions and algorithms, prepare reports and graphics, and access primary input data (2, 10, 13).

Following the DRC analysis mentioned above, a student of the Air Force Institute of Technology (AFIT) utilized LAWS to conduct an analysis on a modification to a piece of electronic, self-protection jamming equipment used on the F-15 aircraft. His assessment of LAWS was that it was a 'promising tool for supportability assessment' (20:157).

LAWS software is undergoing modification to enhance user applicability, the success of the model thus far can

be attributed to the selection and incorporation of the present computer algorithms in use.

Models

The LAWS successfully demonstrated the utility of the model on numerous occasions. The algorithms used in the construction of the LAWS software were borrowed from a variety of existing models which have all been fully validated. Additionally, all of the models used in LAWS have been used in DOD applications for years (2, 18, 19).

The success of the LAWS can partially be attributed to the careful selection of validated algorithms which were incorporated into the final product. Described below are the models which were selected for inclusion into LAWS.

Dyna-Metric model addresses both combat capability, and survivability and has been validated to perform wartime assessments.

Support Systems Effectiveness and Cost model is used to 'model the constraints in steady-state', and it also addresses combat capability and survivability.

Interactive Manpower Personnel Assessment and Correlation Technology, and the Training and Manpower models were used in previous applications to estimate personnel and training requirements in several new Army systems.

Logistics Support Cost Model is the standard Air Force Logistics Command (AFLC) cost model which has been used in a variety of programs.

Aircraft Availability Model is used by USAF in the justification of the Program Objective Memorandums (POMs) and by the AFLC in the allocation of its budgets [8].

Algorithms that best meet the needs of the USAF in making decisions on logistics supportability issues are included in these six models which were chosen from a group of twenty-one possible candidates (10). Part of the rationale for selecting these particular models was because of the manner in which each was designed to accomplish the LSA in much the same manner that the DPML would accomplish the LSA.

LAWS Sensitivity Analysis

The rationale for the implementation of the LAWS program is evident. The most prominent reason is to produce the lowest possible life-cycle cost through proper planning. Also, LAWS is used to aid in product evaluation to insure that the fielded system is reliable, maintainable, and supportable.

LAWS is a tool that aids in the integration and the application of various techniques and functions to insure supportability requirements are considered in the design stage of development.

The DPML is required to review reliability and maintainability characteristics in the design, and evaluate trade-offs in areas like alternative repair policies and levels of maintenance. Additionally, the DPML must determine the extent and use of off-the-shelf equipment, in order to influence the design to enhance

supportability through the appropriate selection of system components and potential suppliers. Lastly, LAWS lends itself well to assessing changes and modifications to existing systems through the use of sensitivity analysis curves to assess trade-offs.

A major effort by AFLC and AFWAL has been to apply the sensitivity analysis ability of LAWS to assess problem areas and to suggest recommended improvement areas in existing systems. This combined effort has come to be called the Logistics Technology Insertion for Existing Systems (LOGTIES).

LOGTIES

LOGTIES is a program with the primary focus of using LAWS to support AFLC offices tasked with developing the Weapon System Master Plan (WSMP) sponsored by USAF/LE. The construct of the WSMP involves development of a 10-year projection of weapon system operational requirements and the identification of necessary logistics support levels to achieve those requirements (14:2.1).

At the present time, various data bases in the USAF provide information on items in the active inventory which limit present warfighting capability. Some of these data bases are the WSMIS, CAMS, REMIS, and TICARRS G333 (19). After a factor that limits the war-fighting capability of a component or system (LIMFAC) is identified as a problem

area, a historical data base has to be established using the available reliability, maintainability, and supportability data extracted from the existing data source, such as the D056, F-16 Centralized Data System (CDS), or TICARRS G333 (19, 14).

Next, LAWS is used to accomplish a supportability analysis of the item. The supportability analysis allows the user to quantify the impact that the LIMFAC has on the composite R&M 2000 goals. At this point, a target can be established which will minimize the impact on the R&M goals. The next step is to determine if alternative technologies are available which can be used to minimize the impact. The LIMFAC is then reduced to the greatest extent possible by using existing technologies to make whatever improvements are possible (14). Regardless of the outcome, LAWS is a tremendous management tool when it is used to project the impact of supportability and maintainability problems on the R&M 2000 capability.

Summary

This background centered around the evolution of the R&M awareness and the evolution of the LAMP and LAWS methodologies to aid in the R&M logistics supportability assessment of improved and existing weapon systems.

With the development of new technologies in an era of computer aided logistics design and analysis, it is

logical to use the computer to the greatest extent possible to decrease the cumbersome and complicated tasks of supportability analysis.

LAWS is a useful tool in the evaluation of design alternatives through the effective use of sensitivity and 'what-if' analysis. The application of LAWS in the LOGTIES program has further enhanced its potential value to present and future USAF procurement managers.

III. Methodology

Overview

Dynamics Research Corporation (DRC) developed the Logistics Assessment Work Station (LAWS) computer program under the Logistics Assessment Methodology Program (LAMP) to assist system program manager's to assess both new or improved weapon system procurements. LAWS design allows sensitivity analysis to be accomplished to determine system compliance with Air Force reliability and maintainability (R&M 2000) goals; increase combat capability, increase survivability, reduce manpower requirements, decrease tonnage of mobility requirements, and optimize life-cycle cost to operate the system.

The purpose of this study was to allow students the opportunity to examine the systemic relationships between design decisions and logistics supportability throughout the life-cycle of the system. To do this, an educational package was developed with a simulated procurement decision problem to allow future acquisition logistics students to have some 'hands-on' experience in using the LAWS software to solve a simulated procurement problem.

The objective of this effort was to allow students to become familiar with the LAMP methodology and how it can be applied to examine logistics supportability issues

of a system. If used properly, the training scenario using LAWS software illustrates the systems relationship between design decisions and their impact on logistics supportability issues.

Data Development

Sources of Information. The AFLC/LOC office at Wright-Patterson Air Force Base (WPAFB) provided DRC with F-16 aircraft maintenance data from the F-16 Computerized Data System (CDS) and the TICARRS G333. Using a compiler designed by DRC, the F-16 CDS data was transposed into a format usable in the LAWS work files. The preliminary F-16 CDS data was used as a baseline for the development of design specifications and performance data for the black box designs.

Design data and non-performance characteristics of the black boxes were generated via common agreement between the thesis advisor and the thesis author using common 'rules of thumb' that are consistent with current USAF guidance and regulations.

Input data that was used by the DRC Corporation in LAWS demonstration disks was manipulated in order to obtain some design specifications and non-performance characteristics of the new black boxes. Manipulation of the data was done with the consensus of several different sources: first, from the AFWAL/FIX office to the extent

that they are the functional area to accomplish this type of logistical assessment; second, from the manufacturer of the software, the DRC Corporation, Fairborn, Ohio; and lastly, from the thesis advisor on the faculty of the AFIT, School of Systems and Logistics, Wright-Patterson Air Force Base (WPAFB), Ohio.

Research Design. The sequence of events accomplished during the research is listed below:

(1) Version 1.2 of the LAWS program and appropriate manuals were obtained from DRC.

(2) Available maintenance and design data on the F-16 aircraft was input into LAWS for use as a baseline to develop the new black box designs.

(3) The design specifications, support requirements and reliability and performance characteristics were input into the LAWS program under specific support scenarios and provided to students to accomplish the analysis.

(4) A simulated procurement problem involving a choice between three design alternatives was presented to the student. The possible choices are discussed later in Chapter IV of this paper.

(5) Students are requested to accomplish a simple analysis of the data to assess compliance with the R&M 2000 goals.

(6) Students are directed to use LAWS to accomplish

a sensitivity analysis to provide data on their selection of the acceptable alternative in the designs.

(7) Probable LAWS outputs are analyzed and included in Chapter V to determine which possible designs allow for the most cost effective operation and allow maximum sortie generation capability to realize peak performance.

LAMP Analysis Stage

The input data was analyzed according to the ten separate ILS elements listed below: technical data, manpower, maintenance planning, supply support, support equipment, computer resources, facilities, training requirements, design interface, and packaging, handling, and transportation equipment.

Method of Accomplishment. The objective of the research was to develop an educational package to illustrate how LAMPs can be used to accomplish a logistical analysis of a system in the design, modification, or acquisition process.

The research design involved computer simulation of three black box designs. This study was exploratory in nature and compared the characteristics of a production black box for the F-16 aircraft, a slightly improved model of the box, and a box with significant improvements and at a significant price.

The LAMP algorithms interpret quantifiable data.

To insure the generation of adequate, reliable data, the research of technical data was supplemented by personal interviews with the DRC and AFLC/FIX.

The utility of LAMPs was established in prior studies and the algorithms were validated prior to the accomplishment of this study. The internal validity of LAWS is enhanced by its design and by the clear distinction and analysis of the ILS elements and the five R&M 2000 goals. The ability to apply LAMPs to other areas is enhanced by the high degree of standardization among acquisition strategies, technical data concepts, and the reliability and maintainability requirements of the U.S. Air Force.

During this study, each of the five R&M 2000 goals were treated as separate dependent variables. The ten ILS elements were treated as separate independent variables. The major emphasis of the research was placed on logistics supportability issues.

There were no significant unusual aspects of the research. The most significant hurdle was to collect and construct maintenance and design data for the black box designs, and then transpose the data into a format usable by the LAMPs methodology.

Information contained on 5.25 inch computer diskettes was provided to AFIT/LSM, for use in future

classroom exercises. A series of batch files was developed and incorporated on the diskettes to facilitate the loading of all new data files into the LAWS subdirectory. Instructions to the students in the form of a 'read.me' text file are also included on the diskette. The 'read.me' text file is provided as Appendix A to this paper. Additionally, the exercise instructions in the 'read.me' file provide criterion for maximum ranges of data manipulation in the accomplishment of the sensitivity analysis. A flow diagram of the recommended procedures for the analysis is included as Appendix B to this paper.

Sensitivity Analysis

Sensitivity analysis involves investigation into areas where the evaluation of the data is not certain. Students are requested to perform sensitivity analysis on one or more of the procurement options. Ideally, students should alter the data slightly to examine possible trade-offs between MTBF and the Life-Cycle Cost (LCC) of one of the design alternatives to determine an optimum design alternative. Most importantly, the analysis should provide limits where the item being investigated will change the outcome of the results.

Summary

This chapter presented a brief description of the

way in which data was gathered along with the method used to accomplish the data analysis. The end result should provide information on the benefits and disadvantages in selecting each one of the three design alternatives. Also, several conceivable changes to each of the three system designs are provided in Chapter V, along with the expected impact of each change.

The resulting educational package provides the capability for professors to ask future students to use LAWS to perform supportability analyses and then provide a recommendation on which of the three design alternatives exhibits the optimum choice, with consideration to the five R&M 2000 goals. Based on the sensitivity analysis, an alternative solution should be provided by the student along with the rationale for the choices.

IV. Design Alternatives

Overview

The purpose of this chapter is to describe how the scenario for the problem was developed, and to describe the particular design alternatives for each of the three procurement options. The variables for each of the design alternatives were discussed in the order that they appear within the context of the LAWS listing of the ten ILS elements. Included in this chapter are the specific performance characteristics, assumptions, and limitations used in the construction of the procurement scenario.

Particular Method

The data on the three designs were input into the LAWS program and analyzed according to the ten separate integrated logistic support (ILS) elements listed below: design interface; scheduled maintenance; unscheduled maintenance; supply support; support equipment; packaging, handling, and transportation; technical data; facilities; manpower and training; and computer resources.

Data values were manipulated so that the output data would present the appearance of relative equivalency in the final analysis. Data values used in the scenario are provided in the following sections.

Supportability Issues

Data input into the LAWS program for analysis have to be inserted into a menu of items categorized according to the ten ILS elements. Each of the data files for 'parts' contains an entry for each of the ILS elements.

The specific details of each of the three design alternatives are listed below according to the appropriate category of ILS element.

Design Interface. Design interface for each part includes the data required to assess the overall MTBF. The input values for design interface include research and development costs, and the physical dimensions of the item. An important feature for estimation of combat capability and survivability is to include the fractional utilization; amount of time the part is used during each sortie. Input data is included in Table I through III.

Table I. Power Supply Unit (88XX0)
Design Interface Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Fractional Utilization (percent per sortie)	1.0	1.0	1.0
Development cost (Thousands of dollars)	00	09	150
Weight (pounds)	40	35	35
Size (Cubic feet)	1.1	1.1	1.1
MTBF (Hours)	100	240	545
Inherent	200	400	1000
Induced	200	600	1200

Table II. Computer Processing Unit (88XY0)
Design Interface Data.

Data Variables	Existing	New	Improved
Fractional Utilization (percent per sortie)	1.0	1.0	1.0
Development cost (Thousands of dollars)	00	20	200
Weight (pounds)	13	13	13
Size (Cubic feet)	1.8	1.8	1.8
MTBF (Hours)	100	240	554
Inherent	200	400	800
Induced	200	600	1800

Table III. Radar Interface Unit (88XZ0)
Design Interface Data.

Data Variables	Existing	New	Improved
Fractional Utilization (percent per sortie)	1.0	1.0	1.0
Development cost (Thousands of dollars)	00	10	120
Weight (pounds)	20	20	22
Size (Cubic feet)	3.2	3.2	3.2
MTBF (Hours)	143	222	554
Inherent	200	400	800
Induced	500	500	1800

Scheduled Maintenance. Scheduled maintenance is the amount of time required to accomplish the routine operations of inspecting, calibrating, and servicing the equipment. Increased frequency of scheduled maintenance correlates to a decrease in the operational capability of the equipment. The next three tables indicate elapsed

flying hours between scheduled maintenance actions.

Table IV. Power Supply Unit (88XX0)
Scheduled Maintenance Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Inspect	10	20	40
Calibrate	10	20	80
Service	00	00	00
<u>Phased Inspection</u>	<u>100</u>	<u>100</u>	<u>160</u>

Table V. Computer Processing Unit (88XY0)
Scheduled Maintenance Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Inspect	10	20	20
Calibrate	40	40	100
Service	00	00	00
<u>Phased Inspection</u>	<u>160</u>	<u>160</u>	<u>320</u>

Table VI. Radar Interface Unit (88XZ0)
Scheduled Maintenance Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Inspect	10	50	50
Calibrate	10	50	50
Service	00	50	100
<u>Phased Inspection</u>	<u>160</u>	<u>160</u>	<u>320</u>

Unscheduled Maintenance. Unscheduled maintenance is the amount of time equipment is out of commission due to

suspected or actual failures. In some cases the equipment may malfunction during operation but the failure cannot be detected on the ground. Additionally, in other cases, the equipment is removed and transported back to the shop for bench check, but the bench tester implies that the equipment is not faulty. Unless indicated otherwise, the values in the next three tables are percentages. Unscheduled maintenance data is included in Tables VII through IX.

Table VII. Power Supply Unit (88XX0)
Unscheduled Maintenance Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Failures that cannot be duplicated	20	20	05
Repair in place	05	10	20
Bench Check Satisfactory	10	05	00
Not Repairable this Station	10	05	02
<u>Base Repair Cycle (Days)</u>	<u>03</u>	<u>03</u>	<u>02</u>

Table VIII. Computer Processing Unit (88XY0)
Unscheduled Maintenance Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Failures that cannot be duplicated	02	01	01
Repair in place	00	00	80
Bench Check Satisfactory	17	15	00
Not Repairable this Station	19	12	00
<u>Base Repair Cycle (Days)</u>	<u>02</u>	<u>02</u>	<u>02</u>

Table IX. Radar Interface Unit (88XZ0)
 Unscheduled Maintenance Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Failures that cannot be duplicated	02	01	01
Repair in place	34	50	70
Bench Check Satisfactory	17	15	00
Not Repairable this Station	08	06	00
<u>Base Repair Cycle (Days)</u>	<u>04</u>	<u>04</u>	<u>02</u>

Supply Support. Supply support includes the cost of the item, as well as the cost of consumable parts used during repair. Additionally, the costs associated with the storage of the replacement parts must be considered. In all cases, the fraction of cost for the part to repair a power supply unit at base level is one percent, and the cost to repair at depot is two percent. Associated costs for the computer processing unit and the radar interface units are five and two, and two and three respectively.

Table X. Power Supply Unit (88XX0)
 Supply Support Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Cost of the part	\$48462.30	\$55876.00	\$66000.00
Cost of consumables			
Intermediate	\$89.00	\$150.00	00
Depot	\$500.00	\$800.00	\$950.00
Supply Management Costs (part per year)	\$9.87	\$9.87	\$9.87

Table XI. Computer Processing Unit (88XY0)
Supply Support Data.

Data Variables	Existing	New	Improved
Cost of the part	\$90500.00	\$110500.00	\$240000.00
Cost of consumables			
Intermediate	\$2.11	\$150.00	00
Depot	\$7.69	\$200.00	\$400.00
Supply Management Costs (part per year)	\$9.87	\$9.87	\$9.87

Table XII. Radar Interface Unit (88XZ0)
Supply Support Data.

Data Variables	Existing	New	Improved
Cost of the part	\$120650.00	\$140500.00	\$180500.00
Cost of consumables			
Intermediate	\$200.00	\$200.00	00
Depot	\$400.00	\$400.00	\$600.00
Supply Management Costs (part per year)	\$9.87	\$9.87	\$9.87

Support Equipment. Support equipment includes all of the equipment used to accomplish both the scheduled and the unscheduled maintenance tasks of removing to repair, to replace, to accomplish routine inspections, calibrations, or phase inspections. A listing of the required support equipment is provided in Table XIII. Tables XIV through XIX display support equipment utilization and are divided according to part and the percent of utilization for the support equipment during either scheduled or unscheduled maintenance.

Table XIII. Support Equipment Data.

Support Equipment	Cost	Weight	Cubic Feet	Square Feet
Mobile Test Set	\$120000	40	05	03
Bench Test Set	\$150000	100	15	60
Depot Test Set	\$200000	5740	2580	320
Support Stand	\$50000	200	60	30

Table XIV. Power Supply Unit (88XX0) Scheduled Maintenance Support Equipment Utilization.

Data Variables	Existing	New	Improved
Inspect (Mobile)	05	05	05
Calibrate (Mobile)	10	10	10
Phase (Bench)	10	10	00
(Mobile)	00	00	30

Table XV. Computer Processing Unit (88XY0) Scheduled Maintenance Support Equipment Utilization.

Data Variables	Existing	New	Improved
Inspect (Mobile)	10	10	10
Calibrate (Mobile)	20	20	20
Phase (Bench)	30	30	00
(Mobile)	00	00	30

Table XVI. Radar Interface Unit (88XZ0) Scheduled Maintenance Support Equipment Utilization.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Inspect (Mobile)	10	10	10
Calibrate (Mobile)	20	20	20
Service (Mobile)	00	00	30
Phase (Bench)	30	30	00
(Mobile)	00	00	30

Table XVII. Power Supply Unit (88XX0) Unscheduled Maintenance Support Equipment Utilization.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Flight Line			
Initial Test (Mobile)	05	05	05
Remove and Replace (Mobile)	10	05	05
Repair in Place (Mobile)	00	00	10
Intermediate Level			
Initial Test (Bench)	30	10	00
(Stand)	30	10	00
Fault Isolation (Bench)	70	35	00
(Stand)	70	35	00
Depot Level			
Initial Test (Depot)	20	10	10
(Stand)	20	10	10
Fault Isolation (Depot)	80	35	25
(Stand)	80	35	25

Table XVIII. Computer Processing Unit (88XY0) Unscheduled Maintenance Support Equipment Utilization.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Flight Line			
Initial Test (Mobile)	20	10	10
Remove and Replace (Mobile)	50	25	25
Repair in Place (Mobile)	00	00	30
Intermediate Level			
Initial Test (Bench)	10	05	00
(Stand)	10	05	00
Fault Isolation (Bench)	90	35	00
(Stand)	90	35	00
Depot Level			
Initial Test (Depot)	10	05	05
(Stand)	10	05	05
Fault Isolation (Depot)	90	35	25
(Stand)	90	35	25

Table XIX. Radar Interface Unit (88XZ0) Unscheduled Maintenance Support Equipment Utilization.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Flight Line			
Initial Test (Mobile)	20	10	10
Remove and Replace (Mobile)	50	25	25
Repair in Place (Mobile)	00	00	40
Intermediate Level			
Initial Test (Bench)	10	05	00
(Stand)	10	05	00
Fault Isolation (Bench)	90	35	00
(Bench)	90	35	00
Depot Level			
Initial Test (Depot)	10	05	05
(Stand)	10	05	05
Fault Isolation (Depot)	90	35	25
(Stand)	90	35	25

Packaging, Handling, and Transportation. This ILS element includes costs associated with packaging, and with the manhours and costs associated with transportation to and from repair facilities. Increased amount of time for transportation relates to decreased in-commission rates of the equipment. Data for packaging, handling, and transportation are included in Tables XX through XXII.

Table XX. Power Supply Unit (88XX0) Packaging Handling, and Transportation Data.

Data Variables	Existing	New	Improved
Packing Weight Ratio	1.9	1.9	1.9
Cost of Packaging (per pound)	\$2.36	\$2.36	\$2.36
Flightline to Shop (Number of Days)	\$1.83 1.5	\$1.83 1.5	\$1.83 00
Shop/Depot/Flightline (Number of Days)	\$3.67 20	\$3.67 15	\$3.67 08

Table XXI. Computer Processing Unit (88XY0) Packaging Handling, and Transportation Data.

Data Variables	Existing	New	Improved
Packing Weight Ratio	1.94	1.94	1.94
Cost of Packaging (per pound)	\$2.21	\$2.21	\$2.21
Flightline to Shop (Number of Days)	\$1.83 02	\$1.83 02	\$1.83 00
Shop/Depot/Flightline (Number of Days)	\$3.67 12	\$3.67 10	\$3.67 10

Table XXII. Radar Interface Unit (88XZ0) Packaging Handling, and Transportation Data.

Data Variables	Existing	New	Improved
Packing Weight Ratio	1.9	1.9	1.9
Cost of Packaging (per pound)	\$2.21	\$2.21	\$2.21
Flightline to Shop (Number of Days)	\$1.83 02	\$1.83 02	\$1.83 00
Shop/Depot/Flightline (Number of Days)	\$3.67 12	\$3.67 08	\$3.67 04

Technical Data. Each item of equipment requires technical data to provide instruction on the proper use, care, and repair of the item. As the piece of equipment becomes more complicated, the amount of technical data increases proportionately. There are costs associated with maintaining and updating each page of technical data.

Table XXIII. Power Supply Unit (88XX0) Technical Data Requirements Data.

Data Variables	Existing	New	Improved
Technical Data (Pages)	100	150	150
Updated Pages per Year	20	20	20
Cost to Update per Page	\$164.50	\$164.50	\$164.50

Table XXIV. Computer Processing Unit (88XY0)
Technical Data Requirements Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Technical Data (Pages)	200	400	500
Updated Pages per Year	30	30	40
<u>Cost to Update per Page</u>	<u>\$164.50</u>	<u>\$164.50</u>	<u>\$164.50</u>

Table XXV. Radar Interface Unit (88XZ0)
Technical Data Requirements Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Technical Data (Pages)	150	200	250
Updated Pages per Year	15	20	25
<u>Cost to Update per Page</u>	<u>\$164.50</u>	<u>\$164.50</u>	<u>\$164.50</u>

Facilities. Each type of maintenance requires certain facilities, listed in Table XXVI, be available in order to accomplish the mission. The goal of future procurements is to reduce the amount of mobility requirements via lessening amounts of support equipment and facility requirements to support the item.

All three of the black boxes require the use of the mobile facility on the flightline. The new and the existing black boxes will require the use of the '1 Shop Set' at the intermediate level of repair, and the '2 Shop Set' at the depot level. The improved version of the box does not require intermediate level repair; however, it still has the same repair levels at depot.

Table XXVI. Facility Data.

Facility	Cost	Square Feet	Annual Cost	Ship Weight	Size Cube
Mobile Shop	\$10000	1000	\$1000	1200	128
AIS	\$20000	1000	\$2000	2400	2580
1 Shop Set	\$80000	1280	\$8000	9600	10318
2 Shop Set	\$160000	2560	\$16000	19200	20636

Manpower and Training. Again, the amount of personnel required to train and to maintain a piece of equipment has a direct impact on the mobility requirements. The fewer the number of personnel, the lesser number of aircraft required to transport them to the operational area. If the number of personnel can be reduced, then the advantage is a reduction in mobility requirements. Provided in Tables XXVII through XXIX is the number of personnel required to perform the scheduled and unscheduled maintenance tasks to support the individual LRUs. LAWS contains a break down of individual tasks and manhours per task according to the scheduled and unscheduled maintenance actions. Actions are listed by the Air Force Specialty Code (AFSC) and the manhours required to perform the action.

Table XXVII. Power Supply Unit (88XX0)
Manpower and Training Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Scheduled Maintenance			
Inspect	423X0 (1.0)	423X0 (1.0)	423X0 (1.0)
Calibrate	423X0 (1.0)	423X0 (0.8)	423X0 (0.6)
Phased	423X0 (4.0)	423X0 (3.0)	423X0 (2.0)
Unscheduled Maintenance			
Flightline			
Initial Inspect	423X0 (0.1)	423X0 (0.1)	423X0 (0.1)
Remove & Replace	423X0 (2.5) 427X5 (1.6)	423X0 (2.5) 427X5 (1.6)	423X0 (2.0) 427X5 (1.0)
Repair in Place	423X0 (3.0) 326X4 (2.3)	423X0 (2.5) 326X4 (2.3)	423X0 (2.5) 326X4 (1.0)
Shop Tasks			
Initial Inspect	423X0 (0.8)	423X0 (0.8)	423X0 (0.0)
Fault Isolation and Repair	423X0 (3.5)	423X0 (3.5)	423X0 (0.0)
Depot Tasks			
Initial Inspect	423X0 (0.8)	423X0 (0.8)	423X0 (0.8)
Fault Isolation and Repair	423X0 (2.5)	423X0 (2.5)	423X0 (2.0)

Table XXVIII. Computer Processing Unit (88XY0)
Manpower and Training Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Scheduled Maintenance			
Inspect	326X4(0.5)	326X4(0.5)	326X4(0.5)
Calibrate	326X4(1.5)	326X4(1.0)	326X4(0.6)
Phased	326X4(8.0)	326X4(6.0)	326X4(5.0)
Unscheduled Maintenance			
Flightline			
Initial Inspect	326X4(0.2)	326X4(0.2)	326X4(0.1)
Remove & Replace	326X4(4.4) 427X5(1.6)	326X4(4.4) 427X5(1.6)	326X4(4.0) 427X5(1.0)
Repair in Place	326X4(0.0)	326X4(0.0)	326X4(1.5)
Shop Tasks			
Initial Inspect	326X4(0.8)	326X4(0.8)	326X4(0.0)
Fault Isolation and Repair	326X4(4.5)	326X4(4.0)	326X4(0.0)
Depot Tasks			
Initial Inspect	326X4(0.8)	326X4(0.8)	326X4(0.8)
Fault Isolation and Repair	326X4(4.0)	326X4(3.5)	326X4(2.0)

Table XXIX. Radar Interface Unit (88XZ0)
Manpower and Training Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Scheduled Maintenance			
Inspect	326X7(1.2)	326X7(1.0)	326X7(1.0)
Calibrate	326X7(2.5)	326X7(2.0)	326X7(1.5)
Service	326X7(0.0)	326X7(0.0)	326X7(2.0)
Phased	326X7(8.0)	326X7(6.0)	326X7(5.0)
Unscheduled Maintenance			
Flightline			
Initial Inspect	326X7(1.2)	326X7(1.0)	326X7(1.0)
Remove & Replace	326X7(2.5) 427X5(1.6)	326X7(2.5) 427X5(1.6)	326X7(2.0) 427X5(1.0)
Repair in Place	326X7(3.2)	326X7(3.0)	326X7(2.5)
Shop Tasks			
Initial Inspect	326X7(0.8)	326X7(0.8)	326X7(0.0)
Fault Isolation and Repair	326X7(4.5)	326X7(4.0)	326X7(0.0)
Depot Tasks			
Initial Inspect	326X7(1.2)	326X7(1.2)	326X7(1.2)
Fault Isolation and Repair	326X7(3.3)	326X7(3.0)	326X7(2.0)

Computer Resources. With the advent of the computer age, comes the requirement for updating and debugging computer software. The input data for computer resources used in this scenario is in Tables XXX through XXXIII.

Table XXX. Power Supply Unit (88XX0)
Computer Resources Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Number of Lines of Data	500	600	800
Development Cost per line	\$3.75	\$3.75	\$3.75
Support Cost per line	\$0.20	\$0.20	\$0.20

Table XXXI. Computer Processing Unit (88XY0)
Computer Resources Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Number of Lines of Data	2000	2200	3500
Development Cost per line	\$3.75	\$3.75	\$3.75
Support Cost per line	\$0.20	\$0.20	\$0.20

Table XXXII. Radar Interface Unit (88XZ0)
Computer Resources Data.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Number of Lines of Data	2000	3000	3500
Development Cost per line	\$3.75	\$3.75	\$3.75
Support Cost per line	\$0.20	\$0.20	\$0.20

All of the items listed above and included in the supportability section of this paper are included in the parts files of the LAWS software. Additional items required to make up the supportability files are reference files. Although facilities, support equipment, and manpower have their own section in the reference files, they were included in the appropriate sections of the parts files. The only section excluded thus far is the

scalar values files.

Scalar Values

In addition to the ten ILS elements, LAWS contains a set of scalar values in a separate set of LAWS data files. Scalar values include items such as the amount of available square feet on a C-141 transport aircraft, or the weight and size of an average maintenance technician. In order to accomplish an impartial comparison of the three different procurement options, the scalar values are held constant for all three procurement options.

Table XXXIII. Scalar Values.

<u>Description</u>	<u>Value</u>
Acquisition Cost of Recruits	\$3200.00
Base Overhead Rate	\$7.29
Depot Overhead Rate	\$19.46
Base Available Manhours per Day	12.00
Depot Available Manhours per Day	8.00
Annual Turnover Rate	0.24
AFSC Upgrade Rate	0.20
Transients, Trainees, Holders & Students	0.01
Average Weight of Man	165.0
Average Volume of Man	12.0
Total Available Hours for Support Equipment.	20.0
Cubic Capacity of C-141 Transport	113990
Weight Capacity of C-141 Transport	71105
Acquisition Cost per Page of Tech. Data.	\$588.00
Manhours to Complete On-Equipment Form	0.08
Manhours to Complete Supply Transport Form	0.25
Manhours to Complete Transportation Form	0.16
Manhours to Complete Off-Equipment Form	0.24

The values shown above were obtained from several official USAF sources and are referenced directly in the LAWS software. The majority of the values are default

values for the LAWS software. Values that were altered were done so with the knowledge of the thesis advisor. Since the same scalar values are consistent throughout the analysis of all of the three procurement items, the actual value of any one particular value will not affect the outcome of the final analysis.

Operational Data Sets

To allow for a better comparison, all three designs of the black box are to be utilized in a simulated tactical environment. The environment is based on the utilization of an F-16 squadron consisting of 24 aircraft. Peace time operations of the squadron entail a requested number of sorties of one per day per aircraft with a maximum number of three sorties per aircraft per day. During war time operations, the requested sortie generation rate will consist of four sorties per aircraft per day for the first seven days. After the first seven days, the requested sortie rate will be reduced to two and a half sorties per aircraft per day. During war-time operations the maximum number of sorties will be maintained at five sorties per day.

The steady state availability of the aircraft will be set at 84 percent. The peace time attrition rate is assumed to be zero. The war time attrition rate is 0.001 or 0.1 percent per day.

All sorties will have the duration of 1.32 hours during either war or peace time operations.

Support Data Sets

The support data set for each of the three black boxes consists of four sections, shown below in tables XXXIV through XXXVII.

Table XXXIV. Parts Support Data Sets.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Peace Time Operations			
Power Supply Unit	02	02	02
Computer Processing Unit	03	03	03
Radar Interface Unit	02	02	02
War Time Operations			
Day 1 through 6			
Power Supply Unit	10	08	06
Computer Processing Unit	14	10	08
Radar Interface Unit	08	08	06
Day 7 through 14			
Power Supply Unit	05	04	03
Computer Processing Unit	07	06	05
Radar Interface Unit	04	04	03
Day 15 through 30			
Power Supply Unit	03	03	02
Computer Processing Unit	04	04	03
<u>Radar Interface Unit</u>	<u>03</u>	<u>03</u>	<u>02</u>

The first file to be addressed indicates the parts availability and delivery during the first thirty days of the war. The amount of spares procured for the War Reserve Spares Kits (WRSK) has a significant impact on the combat capability, survivability, and the life-cycle cost for the system.

Secondly, there is a separate support data set to address the types and quantity of support equipment, manpower, and facilities available for each of the three designs of the black boxes. These too have a tremendous impact on the survivability and capability of the system.

Table XXXV. Flightline Support Data Sets.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Support Equipment			
Mobile Test Set	03	03	02
Personnel			
326X4 Avion Computer Tech.	02	02	02
326X7 Flight Control Tech.	03	03	02
423X0 Elect. Systems Tech.	03	03	02
427X5 Airframe Repair Tech.	02	02	02
Facilities			
Mobile Shelter	01	01	01

Table XXXVI. Intermediate Level Support Data Sets.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Support Equipment			
Bench Test Set	02	02	00
Test Stand	02	02	00
Personnel			
326X4 Avion. Computer Tech.	02	02	00
326X7 Flight Control Tech.	02	02	00
423X0 Elect. Systems Tech.	02	02	00
Facilities			
<u>Intermediate 1-Shop Set</u>	<u>01</u>	<u>01</u>	<u>00</u>

Table XXXVII. Depot Level Support Data Sets.

<u>Data Variables</u>	<u>Existing</u>	<u>New</u>	<u>Improved</u>
Support Equipment			
Depot Test Set	01	01	01
Test Stand	02	02	01
Personnel			
326X4 Avion. Computer Tech.	02	02	02
326X7 Flight Control Tech.	02	02	02
423X0 Elect. Systems Tech.	02	02	02
Facilities			
<u>Depot 2-Shop Set</u>	<u>01</u>	<u>01</u>	<u>01</u>

LAWS Workfiles

After all information is input into the LAWS data files, workfiles are created by the user based on the selection of specific design, support, and operational data sets. A workfile may then be compared to the other existing workfiles in the Data Analysis mode of the LAWS.

Scenario

For this training exercise, complete support sets were developed with all of the variables (Tables I through XXXVII) included. Students were provided explanations of what is, and is not, included in each set. Their task, was to analyze the three sets of data in the tactical operational scenario in order to determine which design choice provides the best solution to the procurement problem with regards to the five R&M 2000 goals. They are asked to consider the trade-offs in using the 'existing' black box and to consider contractor proposals for the modifications to improve black box performance.

Analysis Objective

As a group, students are asked consider the impact of the changes on the R&M goals; determine how the ILS elements are affected; and, present proposals and justification for the selection of procurement action.

V. Data Analysis

This chapter includes information based on the author's interpretations of analyses of the LAWS outputs. The graphs presented as figures in this paper are outputs of the LAWS software and can be produced by a dot matrix or laser printer. LAWS graphics software is designed to be compatible with either an Epson or a Toshiba printer; however, thorough testing is inconclusive. It worked beautifully with a Tandy SX 1000 computer sporting a Tandy Dot Matrix Printer DMP 130.

Overview

To solve the procurement problem, students should be provided with a computer diskette, oral instructions, written instructions (on the diskette), and a flow diagram. The flow diagram (Figure 36), coupled with instructions contained on the diskette, provide enough information to get the problem solver(s) to get some hands-on experience at moving between fields of the LAMP/LAWS environment. Additionally, the flow diagram contains instructions for the accomplishment of a sensitivity analysis of the existing black box assembly.

Information in this chapter is presented in three parts. The first material presented is the combined analyses of the three designs of the three boxes.

Acquisition logistics students are asked to "browse" the files to assess which procurement option provides the best response to fulfill the five basic R&M 2000 goals. The Design Impact on R&M 2000 Goals section of this chapter contains a brief but adequate analysis of the data. This section provides data analysis of preliminary design characteristics and the numbers reflect findings accomplished prior to any sensitivity analysis.

Secondly, the students are provided a flow chart which guides them through a sensitivity analysis of the existing box. The Sensitivity Analysis section of this chapter provides an analysis of each of the three design options. The criterion established by fictitious cost constraints were maximized in the three examples.

Finally, a summary to the chapter presents a synopsis of the preliminary analysis and of the three sensitivity analyses. Lastly, a recommendation for procurement is presented on the design alternatives.

Design Impact on R&M 2000 Goals

The first picture presented of the analysis of the three designs is probably the most meaningful. Figure 1 is a graphic description of the ability of the three designs to meet the five R&M 2000 goals. Although some of the variables (training and facility requirements) are not depicted in this figure, the picture shown here is the

culmination of the ten independent ILS elements.

LOGISTICS ASSESSMENT WORK STATION
VIEW A: WORKFILES AND R&M 2000 GOALS

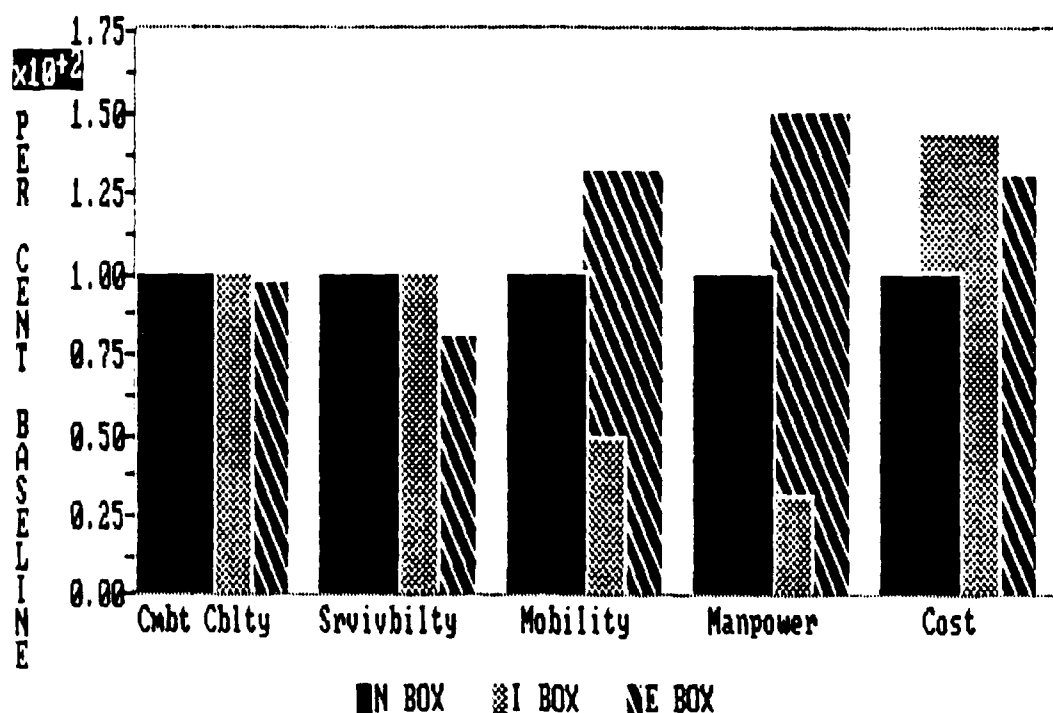


Figure 1. Workfiles and R&M 2000 Goals (View A).

Both the improved box (IBox) and the new box (NBox) portray that they possess 100 percent of combat capability and survivability as opposed to the existing box which has 98 percent and 81 percent respectively. The new box which was selected for the baseline shows 100 percent across the board. This may be misleading, but the graph does show in one quick glance how the three designs stack up against one another. Further analysis is required.

The improved box represents a 279 percent decrease

in the area of mobility requirements (4.51 rather than 12.53 aircraft) over the existing box. The new box showed an impressive 130 percent decrease (9.47 aircraft) from the existing system.

The number of manpower authorizations required to support the systems showed some marked improvements over the existing box; 0.63 personnel per aircraft. The improved box had a reduction to 0.13 personnel, and the new box had a reduction to 0.42 personnel per aircraft.

As far as straight-line costs are concerned, the new box displayed the best overall life-cycle cost (LCC) of \$1843 million over a twenty year period. The existing box would cost \$2401 million (30 percent higher), and the improved box would cost \$2645 million (44 percent higher). Of course, the costs are not the most crucial factor because we all know that quality has a price. The real problem comes in justifying the 'higher' price tag. The problem now turns to one of assessing capabilities and improvements offered by the three different systems.

Combat Capability. The next most logical point to address is the area of combat capability. Combat capability is the culmination of many aspects of the supportability issues. Major determinants of the combat capability are items such as the MTBF which determines the average failure rate and impacts the amount of FMC aircraft. Additionally, the amount of spare parts has a

tremendous affect on combat capability. The next eight figures depict the assessment of the combat capability of the three designs.

Expected Number of Sorties. Figure 2 portrays the expected number of sorties for both peace time, and for the first 30 days of a war. As you can see, all three of the design are capable of meeting peace-time requirements. Again, the IBox shows the ability to meet 100 percent of the required 96 to 60 sorties per day. The NBox shows negligible degradation while the initial degradation of the EBox is painfully obvious.

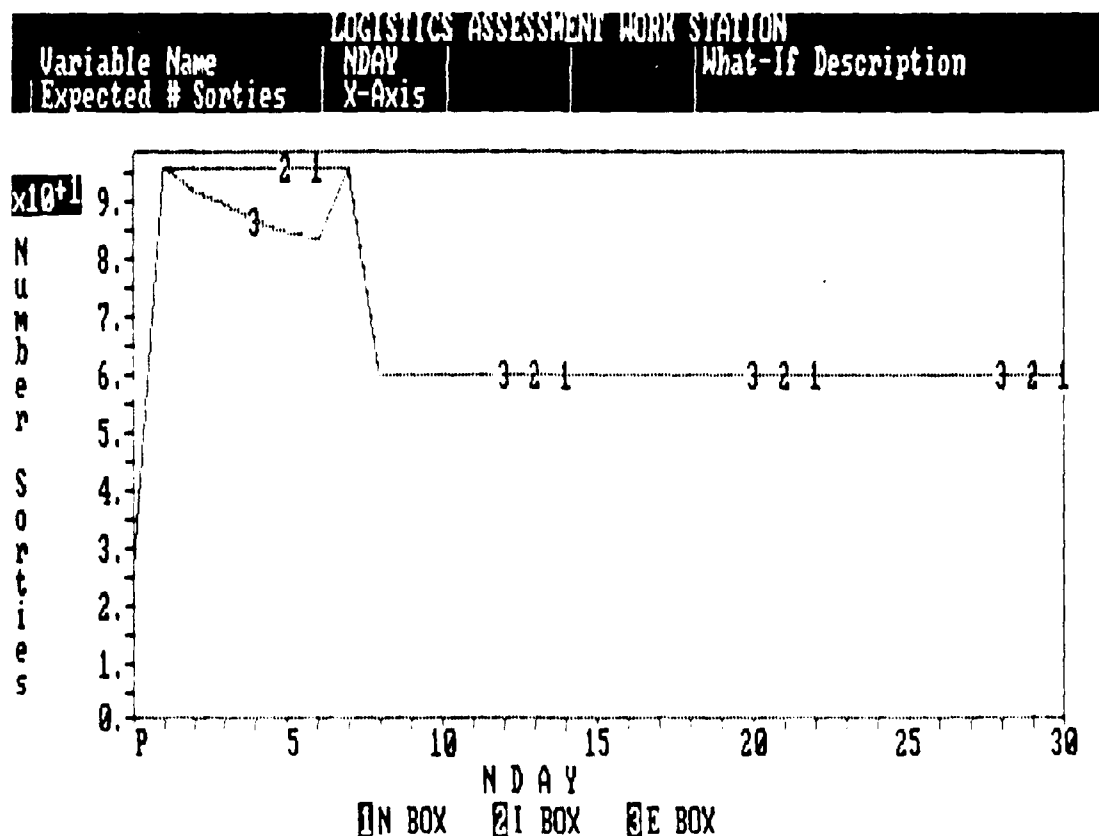


Figure 2. Expected Number of Sorties (View B).

Expected FMC Aircraft. Figure 3 depicts the number of fully mission capable (FMC) aircraft that are expected to be available based on the spares availability and performance characteristics of the three systems.

The IBox is shown as a significant improvement over either the new or the existing box. On an average, the improved box measures at 12 percent better than the new box, and 30 percent better than the existing box.

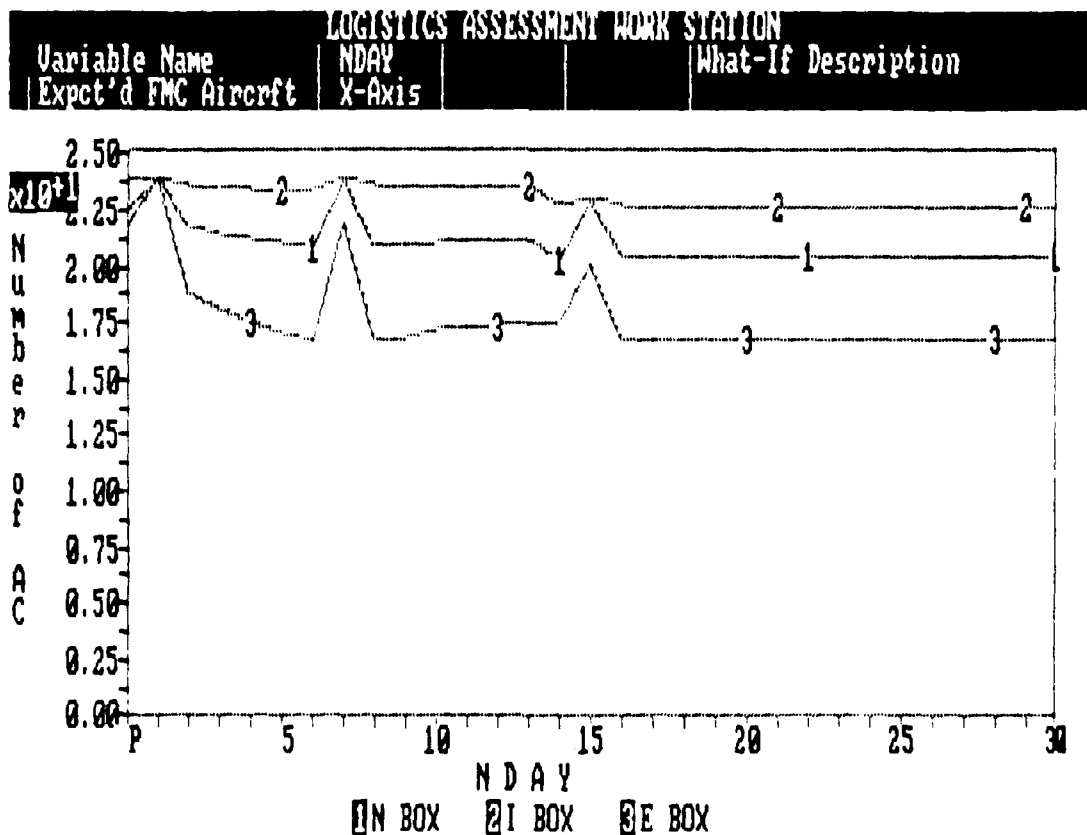


Figure 3. Expected FMC Aircraft (View B).

Expected Back-Order. Based on the support packages selected for the system, the number of back orders is determined. The number of back-orders also tells a story about the reliability of the systems. Figure 4 is a bar chart depicting the number of back-orders predicted during peace-time operations. It is apparent that the number of back-orders expected from either the NBox or the IBox during peace-time is a significant improvement over the existing box.

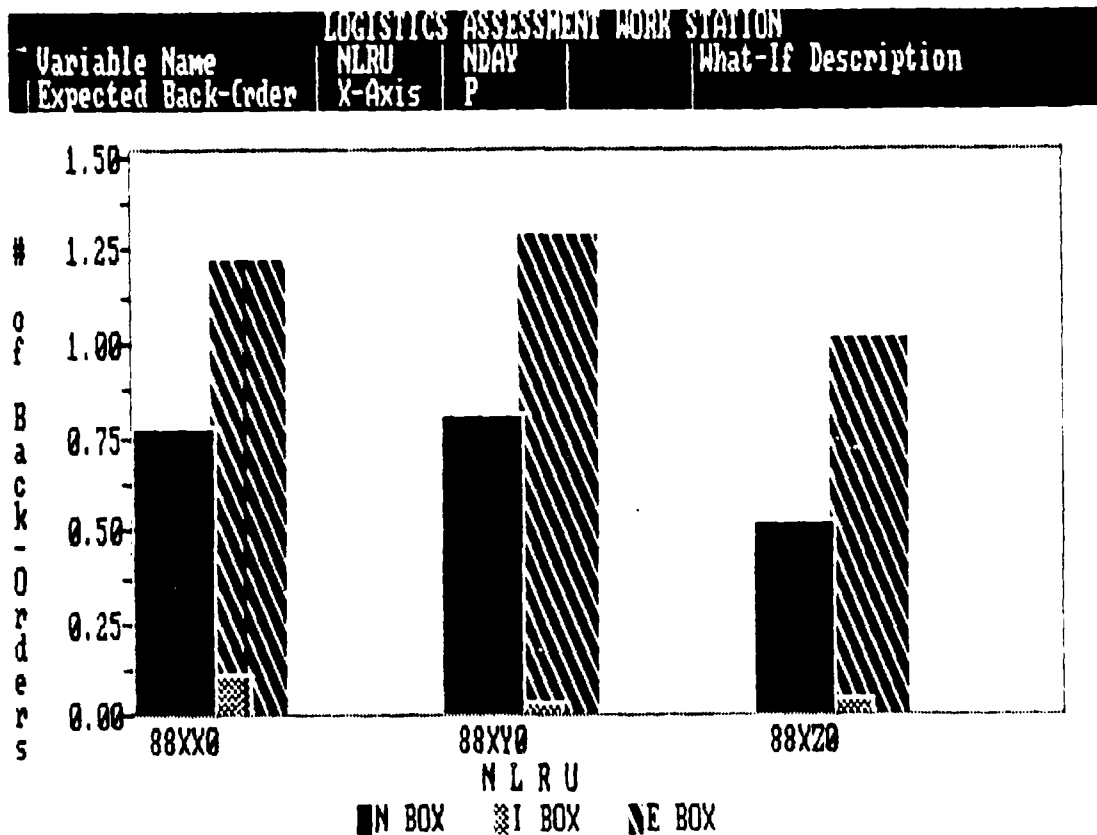


Figure 4. Peace-Time Expected Back-Orders (View B).

Figure 5 shows the cumulative amount of back-orders expected during the first thirty days of the war. The increased capability of the improved box is much more apparent during a conflict, as displayed by Figure 5. The high sortie rates and increased usage of equipment during increased flying hours makes the advantages of having a greater MTBF more pronounced. Of course, there is still a question that has to be answered concerning the benefits of the improved system when the cost is so much more than the existing equipment.

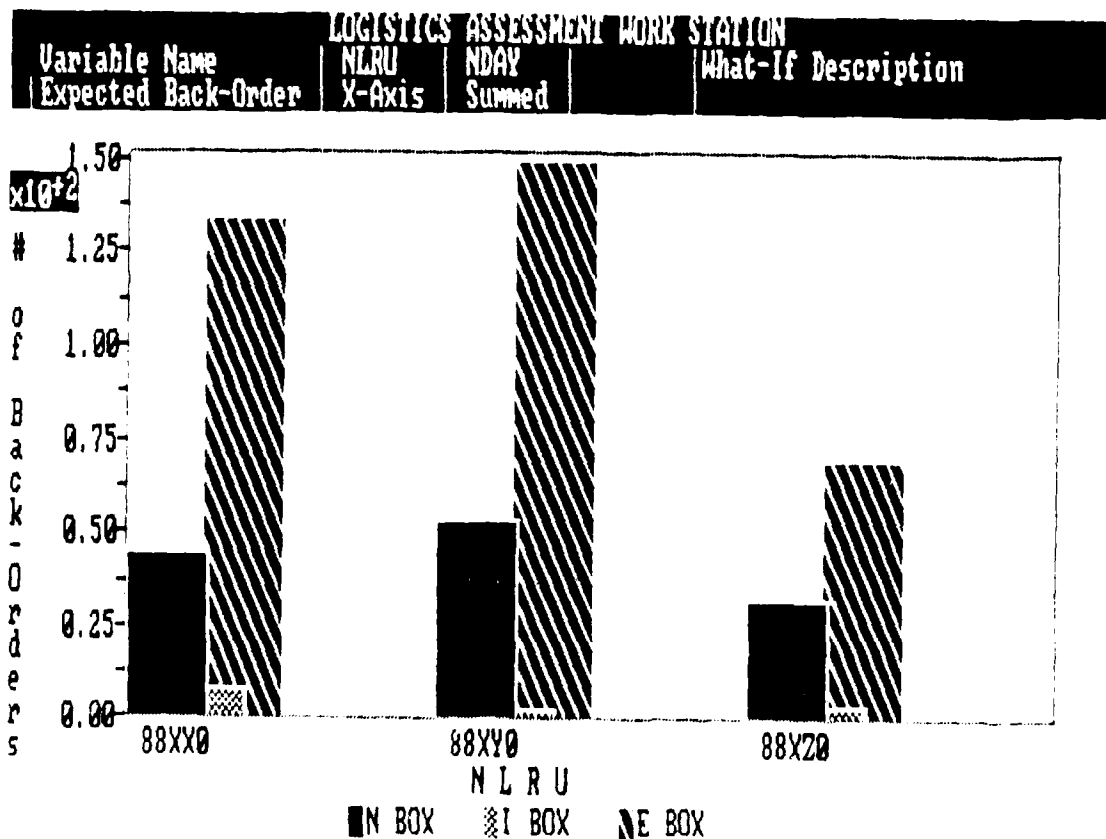


Figure 5. Summed Expected Back-Order (View B).

Sorties Without Maintenance. Just like the number of expected back-orders, the number of sorties without maintenance tells a story about the capability of the weapon system. The existing box is expected to complete only 22 sorties, the new box is expected to complete 49 (a 220 percent improvement), and the improved box is expected to complete 135 (better than a 600 percent improvement). Figure 6 displays the increased capability of the IBox design.

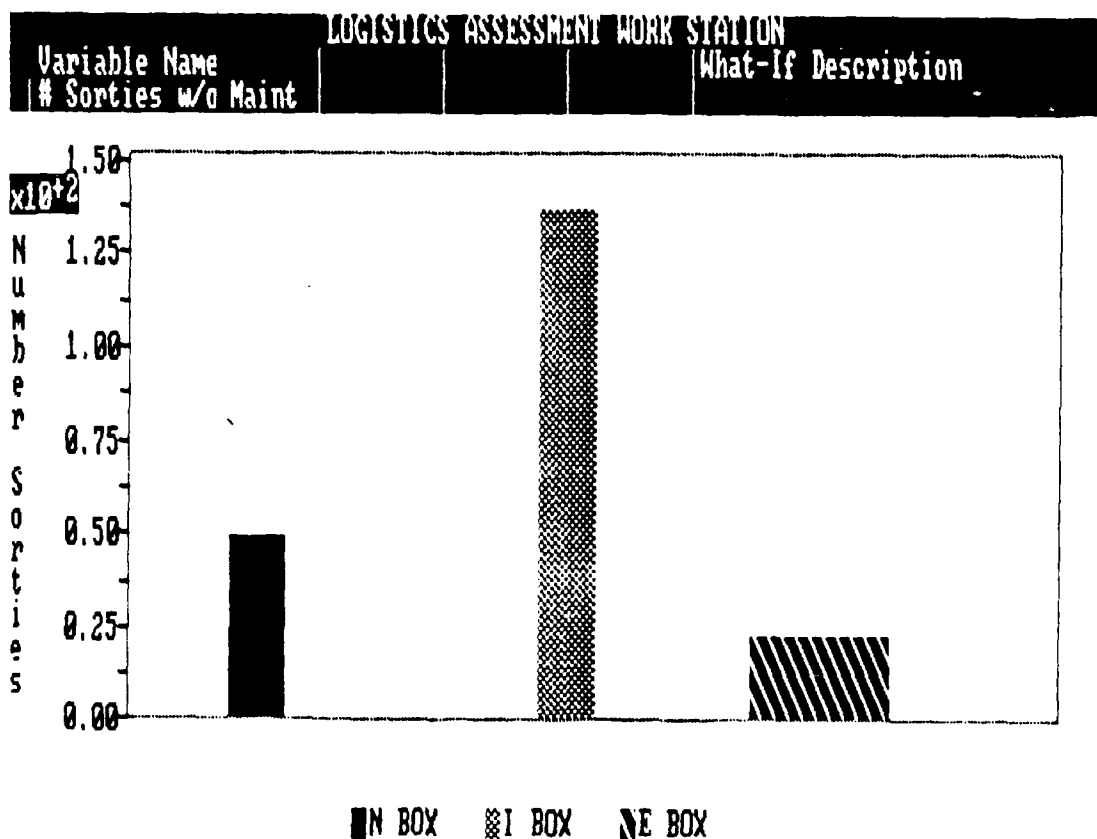


Figure 6. Number of Sorties Without Maintenance (View B).

Average Failure Rate. The average failure rate is determined by the number of times the system is predicted to fail during every thousand hours of flight. The IBox is predicted to fail 6 times, the NBox will probably fail 15 times, and the existing box is predicted to fail 34 times. The greater the number of failures per every thousand hours of flight equates to decreased combat capability. Figure 7 displays the data described above.

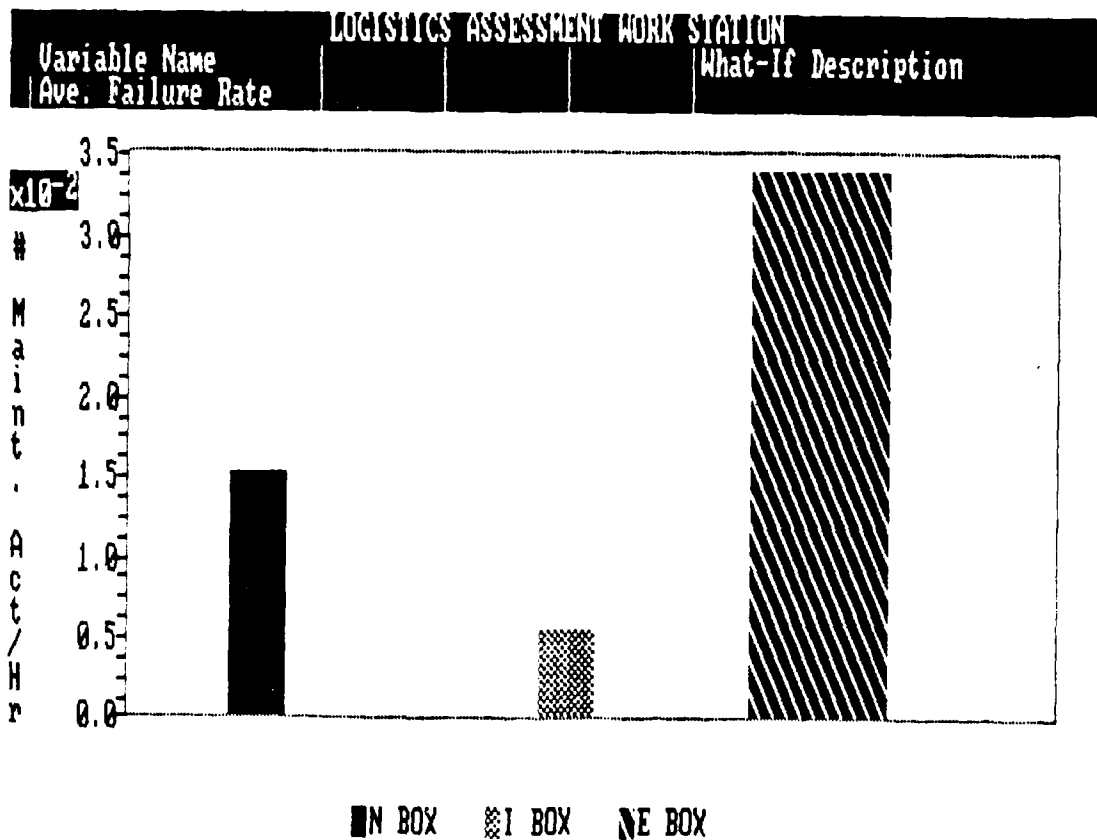


Figure 7. Average Failure Rate (View B).

Survivability. One of the biggest determinants of the ability of a system to survive is the amounts of sorties the system is able to accomplish without I-Level maintenance. As you recall, the IBox was developed without the requirement for I-Level maintenance due to its built-in-test feature and its modular design. The graph below shows the capability of the improved box meet all tasked missions. The NBox shows a slight degradation during the first part of the war, but it soon is able to generate 100 percent of the requirement. Lastly, the existing box shows the capability to sustain only the

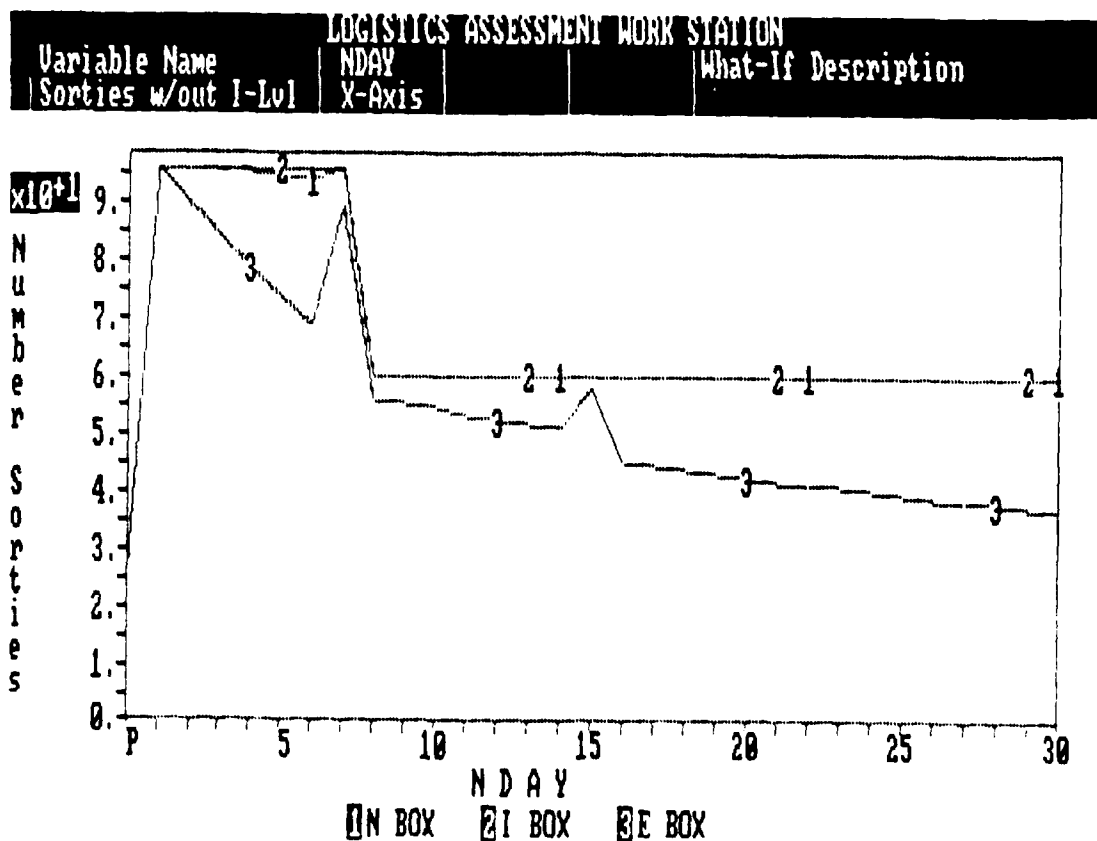


Figure 8. Sorties Without I-Level (View B).

peace-time operations. Not only was it a problem in the past, but it is apparently going to continue to be a problem.

Mobility Requirements. The two biggest factors in determining the mobility requirements section of the R&M 2000 goals is the cubic capacity and the weight of the deploying force required to support the systems. Capacity and weight are shown in Figures 9 and 10 respectively. The amount of cubic feet is 39,500 for the improved box, 88,500 for the new box, and 117,200 for the new box.

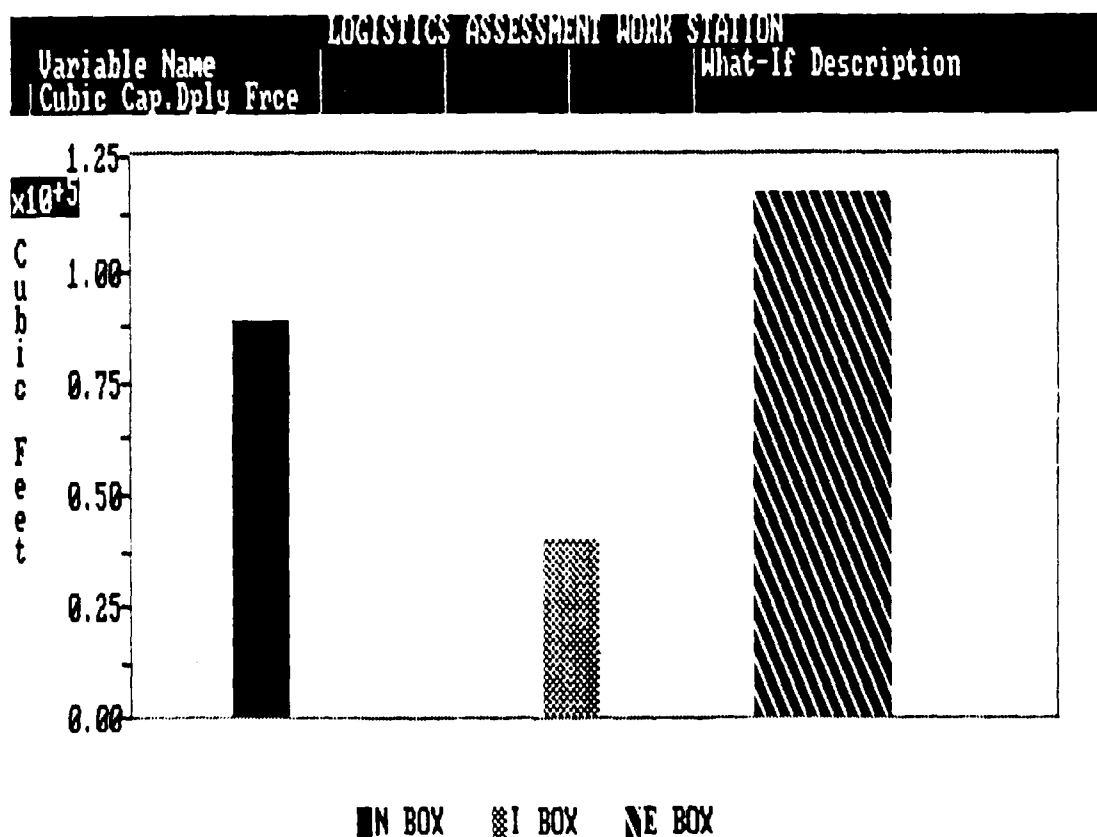


Figure 9. Cubic Capacity of Deploying Force (View B).

The weight capacity of the deploying force also plays an important role in determination of meeting the goal of 'decreasing' mobility requirements. In tonnage, the improved box requires 160.35 short tons as compared to the 336.6 short tons for the new box and 445.4 short tons for the existing box. The total tonnage includes spare parts and packaging in the War Reserve Spares Kit (WRSK), personnel, required support equipment, and the flightline and shop facilities. These factors combine to determine the number of deploying C-141 aircraft required for the first 30 days of conflict.

LOGISTICS ASSESSMENT WORK STATION			
Variable Name			What-If Description
Weight Deploy Forces			

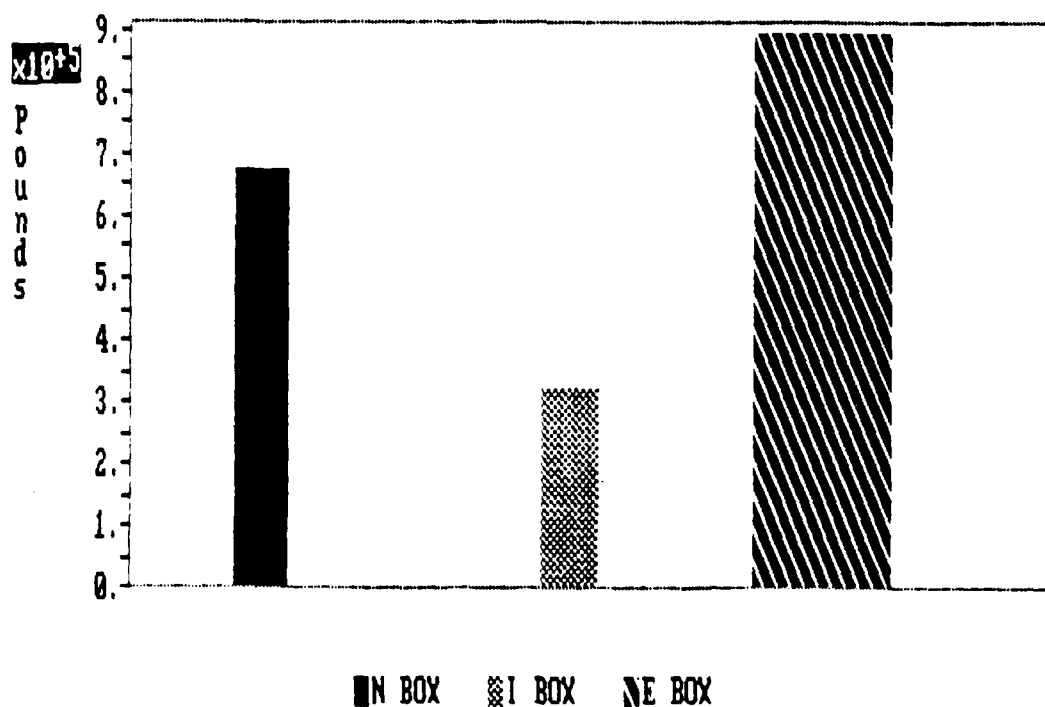


Figure 10. Weight of Deploying Force (View B).

Manpower Spaces Per Aircraft. The bar graph below portrays the number of C-141 aircraft necessary to transport the number of personnel required to support the systems. On the graph, the different numbers represent four different types of AFSCs required to maintain the system. The four types of AFSCs are avionics personnel, electricians, crew chiefs, and sheet metal workers. Due to inspection, service, calibration, and maintenance to the systems, personnel requirements to support the existing box are significantly higher than the other two.

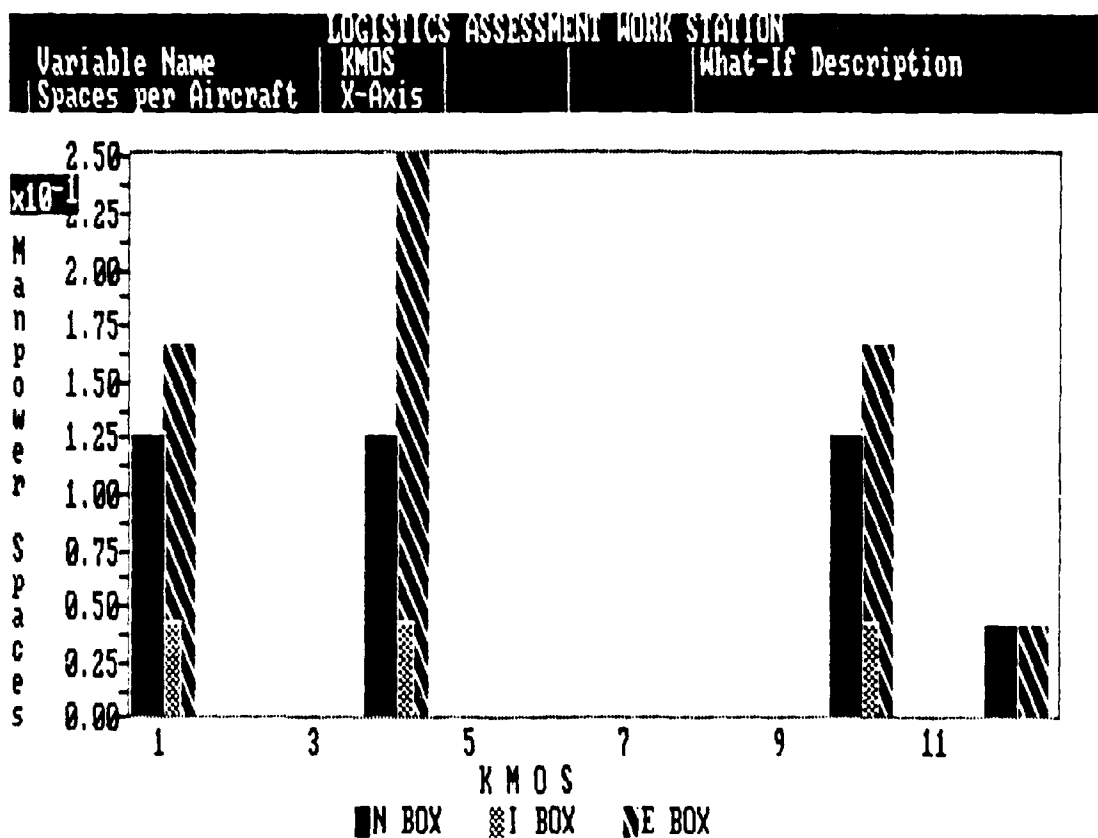


Figure 11. Manpower Spaces Per Aircraft (View B).

Life-Cycle Cost. The life-cycle cost (LCC) of the systems are listed in several different components. Below is a listing of the costs which comprise the total LCC; Total Research and Development Costs (TRDCST), Acquisition Cost (ACQCST), and Total Operations and Support Cost (TOSCST). There was an R&D cost associated with the new and the improved boxes; \$39,000 and \$470,000 respectively. Since the graph below depicts billions of dollars, the R&D costs are insignificant. The LCC of the systems are \$1.84 billion for the existing box, \$2.645 billion for the improved box, and \$2.4 billion for the new box.

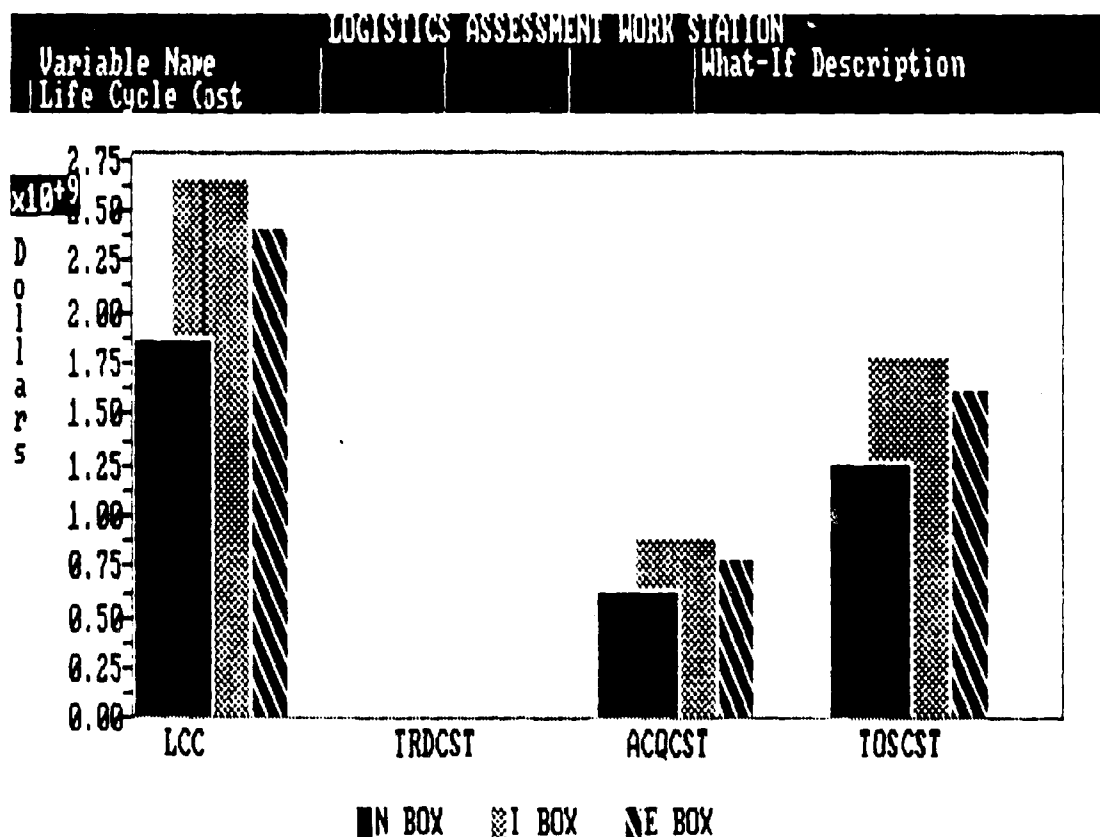


Figure 12. Life-Cycle Cost (View B).

Facility Costs. Although not a significant part of the total LCC, there are costs associated with maintaining the different types of facilities required to support the systems. The graph below portrays the costs associated with the annual maintenance of the different types of those facilities. Abolishment of the I-Level maintenance for the improved box had a significant impact. The amount of maintenance and phase inspections also plays a role in the costs associated with the facilities. The projected annual costs are \$308,000 for the existing box, \$231,000 for the new box, and \$28,400 for the improved box.

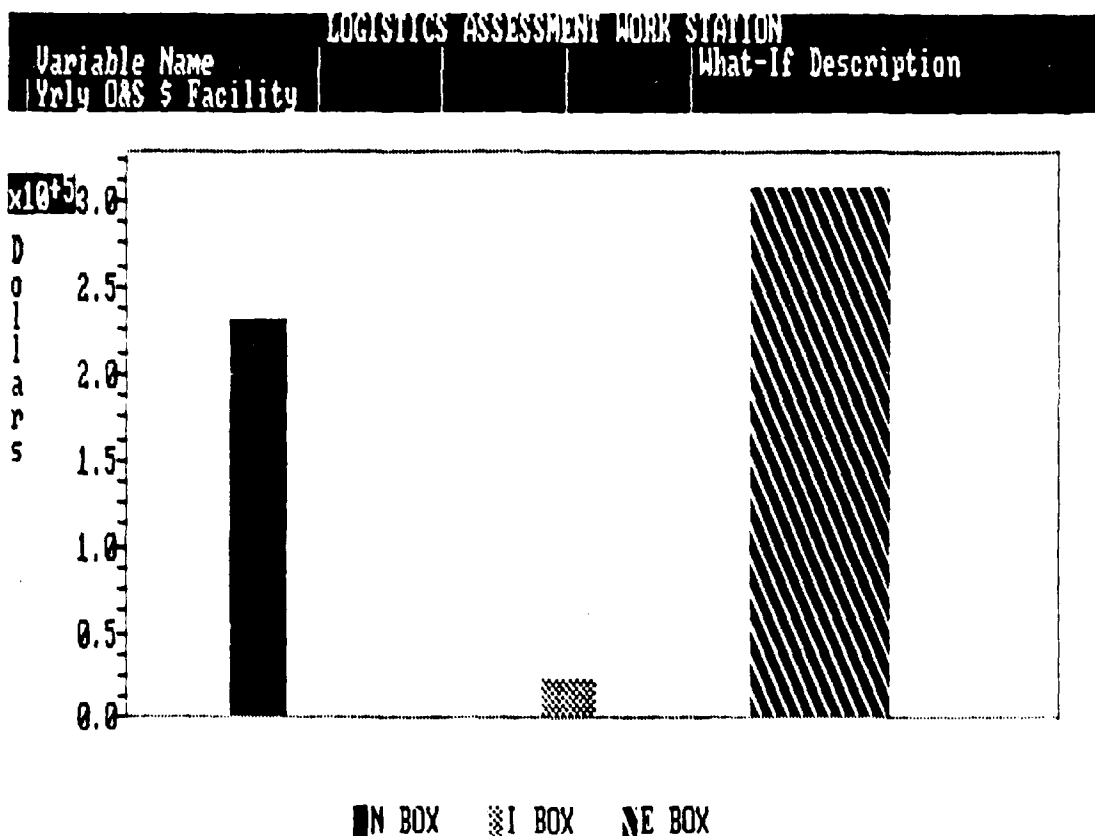


Figure 13. Yearly O&S Cost of Facility (View C).

Training Costs. Figure 14 provides information on costs of training personnel to support the systems. The data includes the annual cost to upgrade personnel and to train because of attrition. The costs are then multiplied by the number of personnel; based on the workload of the system. LAWS analysis predicts the annual requirements to be \$1.13 million to train personnel to support the existing box, \$0.75 million to train personnel for the new box (a 34 percent reduction), and \$0.229 million to train personnel for the improved box (an 80 percent reduction).

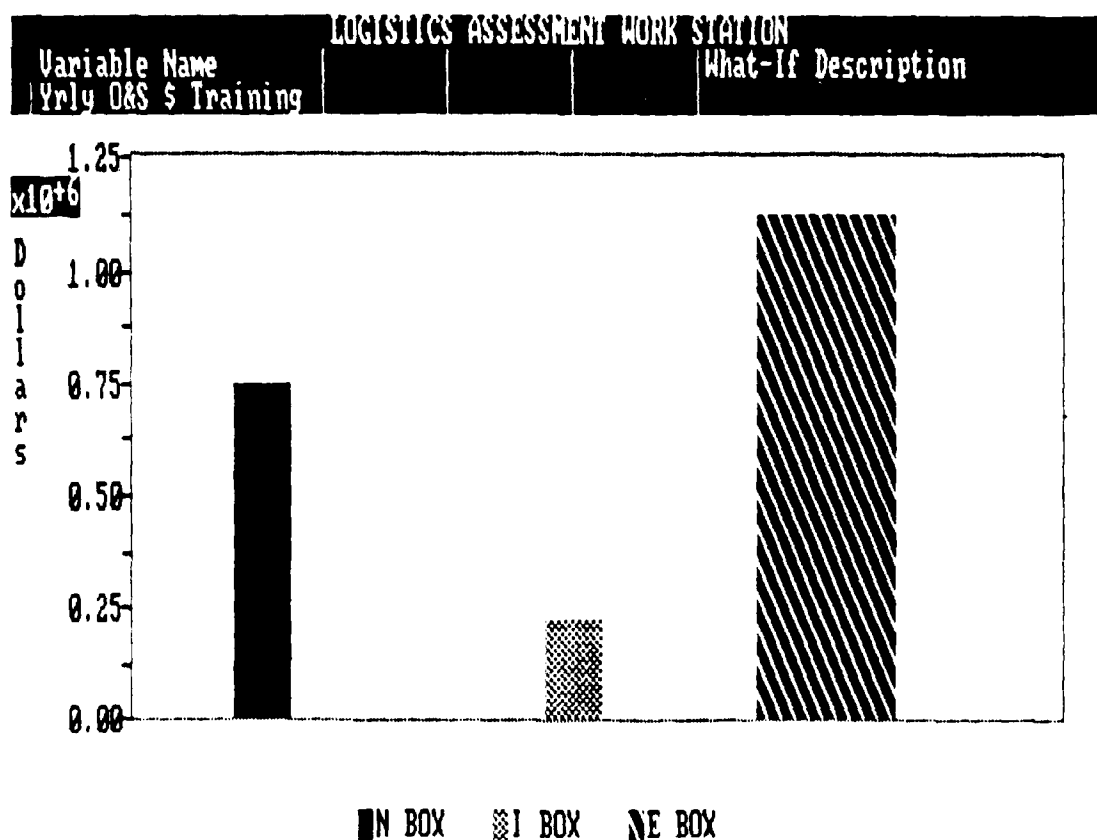


Figure 14. Yearly O&S Cost to Train (View C).

Summary. As a result of data analysis, it is obvious that the procurement decision is clearly between the improved box and the new box. Except in a strictly peace-time environment, the existing box simply cannot meet operational requirements. Even in peace-time, the frailty of the item leaves a lot to be desired. It is cost prohibitive to consider making the same mistake twice by purchasing another copy of a bad design.

That brings us around to a selection between the new box and the improved box. As in the real world, a clear winner is not an easy selection. There is no 'most logical' choice.

To cover the systems in a logical order, one should first point out the good and bad points of the new box. It is a clear improvement over the existing box. At a cost reduction of 24 percent due to increased reliability and maintainability, the new box does have many admirable points. The combat capability and survivability of the system are definitely comparable to the improved box. It possesses the capability to produce twice as many sorties as the existing system, and the MTEF is twice as good as the existing system. Furthermore, the projected number of sorties without I-Level maintenance is comparable to the improved system.

On the other hand, the new box has some bad points. It is predicted to produce only one third as many sorties

without maintenance, as opposed to the improved box, and it has an MTBF that is half as much. Another drawback is that the new box requires twice as many aircraft as the improved box to transport all of the required equipment and personnel for system support. The projected number of back-orders is estimated to be seven times as much over the first 30 days of a conflict. The manpower required to support the system is twice as much as the improved system and the associated weight to deploy the personnel, spares, and support equipment are also twice as much. All in all, the new box has many good points, but it does have its drawbacks. The way the decision sways is dependent on the weight assigned to each of the variables mentioned above.

Most of the pros and cons for the new and improved box are summarized above. There are still a few items which are worth mentioning again. For instance, the expected number of FMC aircraft for the improved system is predicted to be better by an approximate daily average of two aircraft per day during the first 30 days of a conflict. Additionally, the number of C-141 aircraft required for mobility is significantly reduced. This factor could carry considerable weight in light of the present distribution capabilities of the Military Airlift Command and the Civil Reserve Air Fleet. The manpower required to support the improved box is another big plus in its favor. As presented by General Russ in his article

cited earlier in this paper, 'Even if we [USAF]...could afford the price for training and salaries, there is no assurance that larger number of high-quality people will be available' (17:122).

At a glance, the new box appears to meet the requirements established by the user, and it is able to do so at lesser cost than the existing system. Accordingly, the new box is the most logical choice as far as cost and performance are concerned. Still, the issues of reliability and maintainability are not as simple to assess as a price tag.

Procurement of the improved box is recommended because of the obvious benefits associated with its increased reliability, and its reduced manpower and mobility requirements. Because of its increased cost, it would be very difficult to justify its procurement to a congressional budget or appropriations committee.

Fortunately, the LAWS has the capability to accomplish sensitivity analysis. Therefore, before a final decision is made, further analyses are required to ensure that all avenues have been covered.

Sensitivity Analysis

The scenario of this procurement problem states that two of the three parts for each of the systems can be enhanced via an Engineering Change Proposal. The criterion for the enhancement is that the MTBF can be increased a total of 20 percent at a cost of up to \$20,000 per part. The cost for the increase in the MTBF is equivalent to \$1,000 for each gradient increase in the MTBF. Review of the expected back-orders, Figure 4, provided the necessary information to determine which two of the three parts required possible enhancement.

Because the sensitivity analysis for this scenario only addressed the MTBF and the per unit cost of the part, the mobility and manpower requirements were unaffected. Therefore, manpower and mobility goals of the R&M 2000 Goals will not be revisited. The only three factors of the R&M 2000 Goals affected were the combat capability, survivability, and LCC.

Existing Box Design. A two-step increase of 10 percent each was accomplished on parts 88XX0 and 88XY0 for the existing box. The procedure accomplished for this event is described in the flow diagram, Figure 36.

The ability of the modified parts to meet the five R&M 2000 Goals is shown in Figure 15. Again, since the new box was the middle procurement choice, it was selected to be the benchmark to allow for a comparison of the

ability of each of the other two to meet the R&M goals. As predicted, the mobility and manpower goals did not change. Although not visible on the graph, the 20 percent change in MTBF brought about a total reduction of \$90,000 over the LCC of the system. That fact, coupled with the modest increase in combat capability (one percent), and a slight increase in survivability (81 to 90 percent), indicate that the decision to invest the money for the increased MTBF would be prudent. However, this is still not the best procurement option for reasons given later.

LOGISTICS ASSESSMENT WORK STATION
VIEW A: WORKFILES AND R&M 2000 GOALS

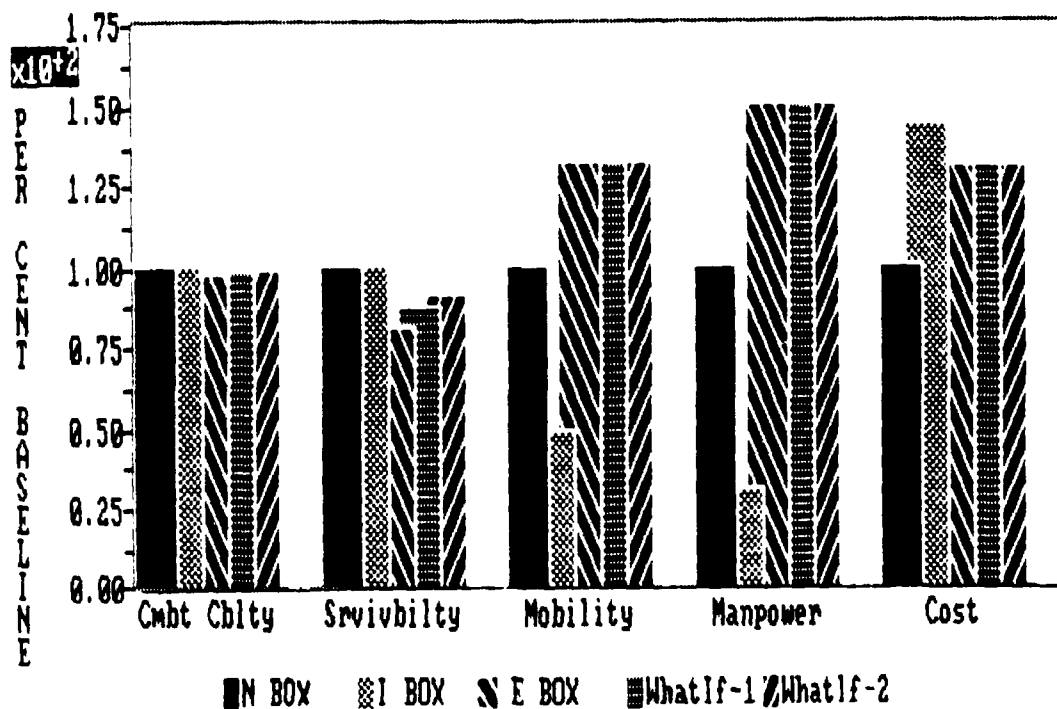


Figure 15. Workfiles and R&M 2000 Goals (View A)
Existing Box What-if Analysis.

Figure 16 depicts the increase of the MTBF affect on the expected number of sorties. The most dramatic change in the graph is seen at day number six when the change of 20 percent on the MTBF allows for an increase from 82 to 87 of the scheduled 96 sorties. During the most crucial part of the conflict, the difference of five more sorties could make a difference. In fact, the improvement of even one sortie could be worthy. After additional parts are received and the sortie requirement is relaxed a little, the existing box is able to meet mission requirements.

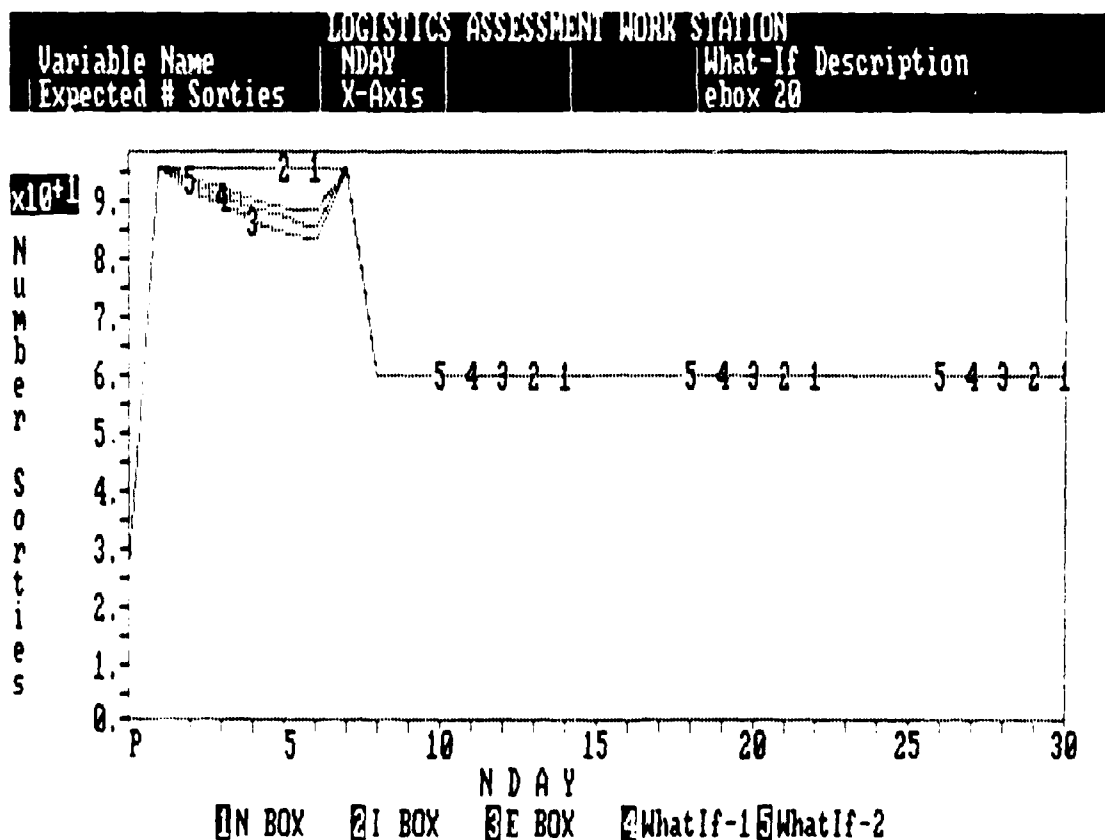


Figure 16. Expected Number of Sorties (View B)
Existing Box What-if Analysis.

The increase in the expected number of FMC aircraft is shown below in Figure 17. There is a slight difference in the ability of the existing box to meet peace-time requirements; however, the difference equates to only portions of an aircraft. Since the entire aircraft is usually required to be FMC and take off at the same time, the difference is moot. The same condition holds true for a ten percent increase in the MTBF, usually only portions of an aircraft were upgraded. The increase of 20 percent in MTBF resulted in an average of one more FMC aircraft.

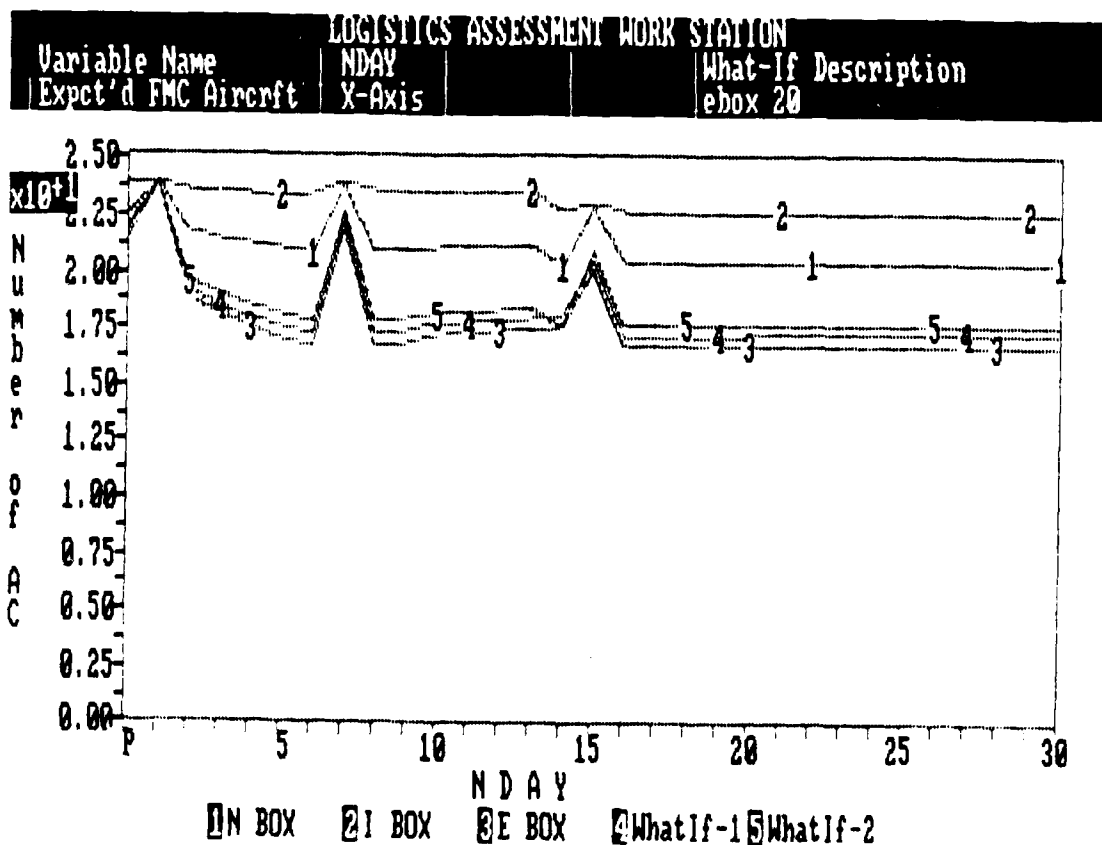


Figure 17. Expected FMC Aircraft (View B)
Existing Box What-if Analysis.

The increase in the MTBF had a significant impact on the reduction of back-orders during a conflict. A graphic display of back-orders is below in Figure 18. Part 88XZ0 was not changed in the analysis. Since 88XZ0 was not the long pole in the tent, the availability of this part did not affect the other outcomes of combat capability or survivability. Part 86XX0 realized a reduction from 132 to 109 back-orders, while part 88XY0 reduced from 148 to 122 back-orders; both reduced 18 percent. This increase assisted combat capability, FMC rates, and survivability.

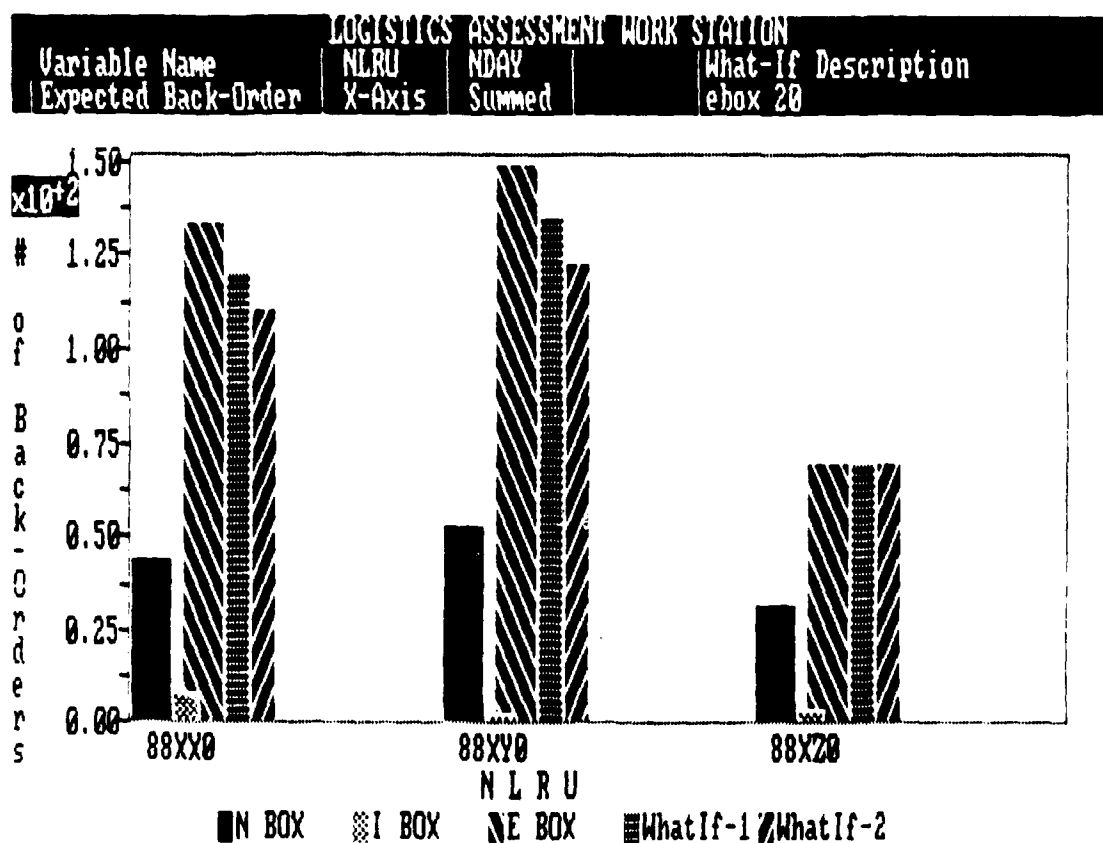


Figure 18. Summed Expected Back-Orders (View B)
Existing Box What-if Analysis.

The number of sorties without maintenance for the existing box is extremely shy of the possible number of sorties from either of the other two alternatives. Figure 19 below portrays the impact that the 20 percent increase in MTBF had on the existing box. The result was an increase from 22 to almost 26 sorties for the existing box without any maintenance.

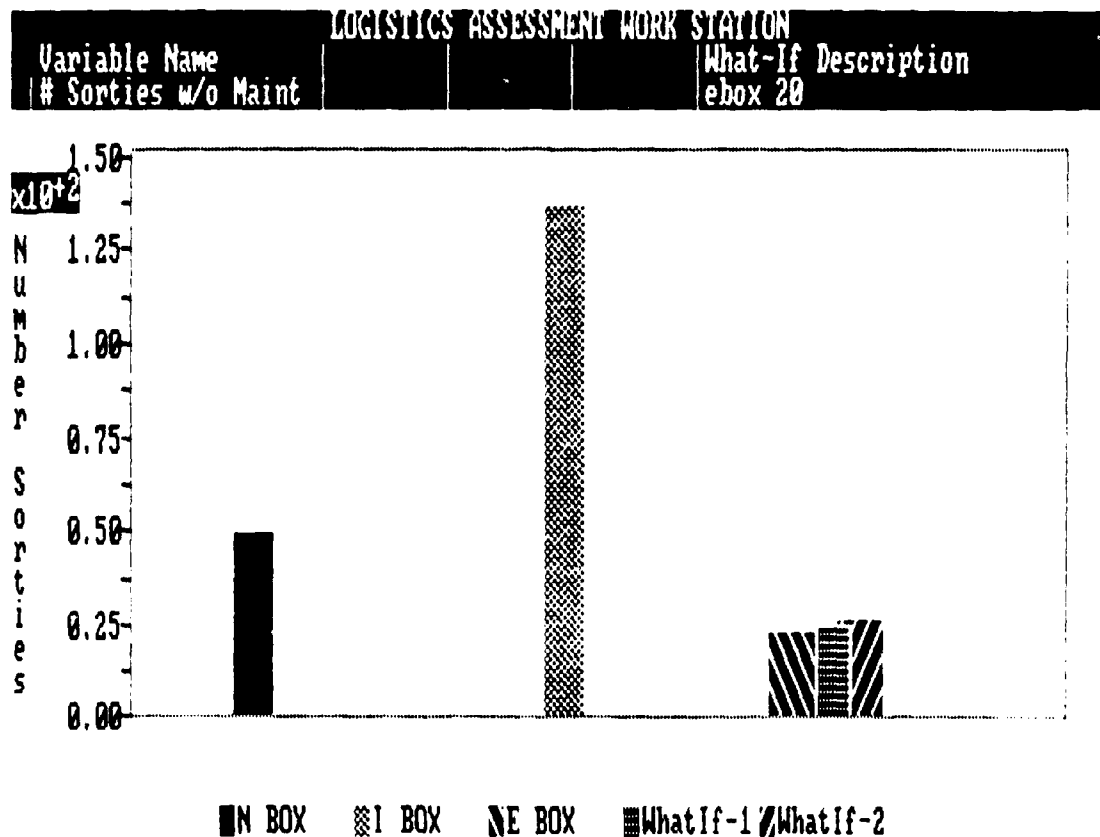


Figure 19. Number of Sorties Without Maintenance (View B)
Existing Box What-if Analysis.

The average failure rate of the system should show significant improvement when the MTBF is increased. Yet, this depends on several things. First, 20 percent of a small amount is an even smaller amount. Secondly, there may be a hidden factor like "another part" being the high driver involved which affects the overall failure rate. At the onset, the failure rate of the existing box was predicted to be 34 failures per every 1000 hours of operation. A 20 percent increase in MTBF of two parts resulted in a change to 30 failures per every 1000 hours.

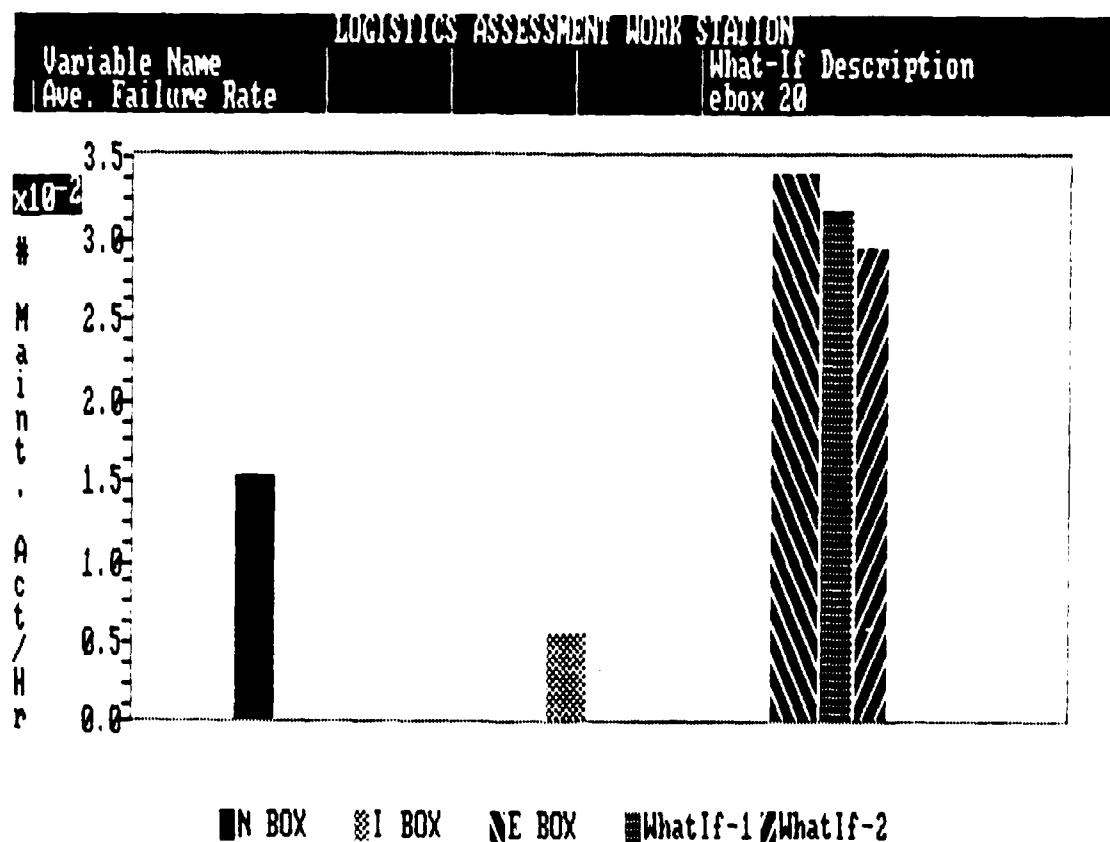


Figure 20. Average Failure Rate (View B)
Existing Box What-if Analysis.

It is apparent in the graph below that the 20 percent increase in MTBF does have an affect on the predicted number of sorties without intermediate level maintenance. The problem here is that it still is not good enough to make everyone want to jump up and buy an 'existing box'. The differences in the number of sorties ranged from none, on several occasions, to as much as 14 on day number 30 of the war. An average number of sorties increase would be between four and five sorties (about 8 percent).

LOGISTICS ASSESSMENT WORK STATION			
Variable Name	NDAY		What-If Description
Sorties w/out I-Lvl	X-Axis		ebox 20

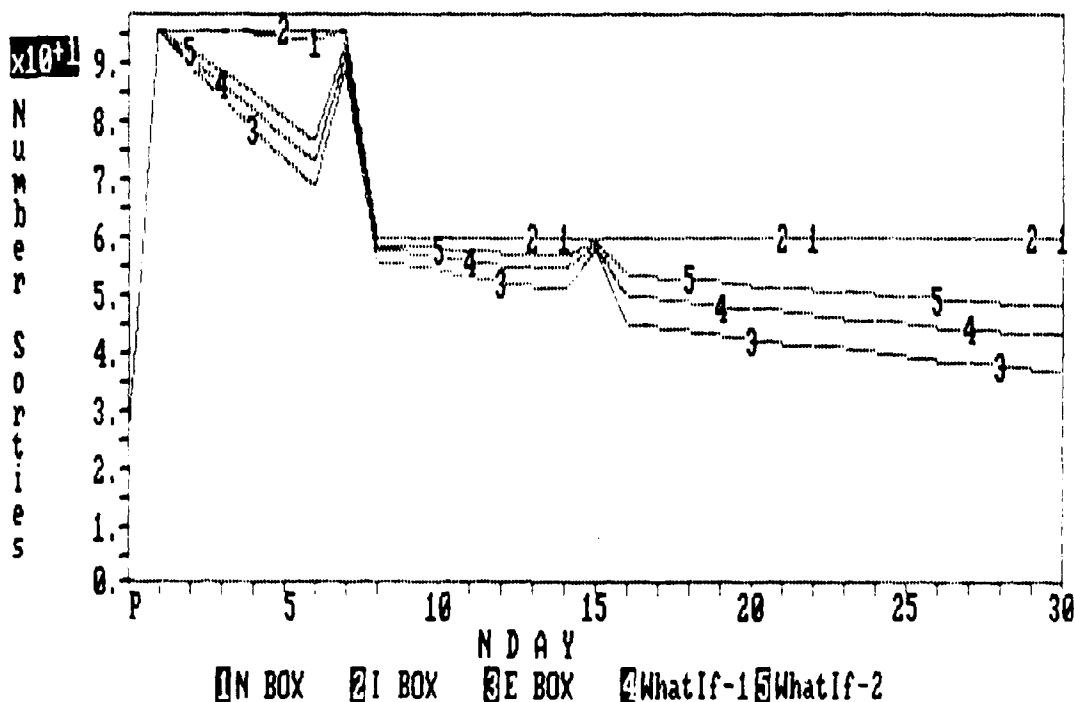


Figure 21. Sorties Without I-Level Maintenance (View B)
Existing Box What-if Analysis.

Considering that the LCC of the item is reduced, any benefits derived from the transaction are welcomed. If the cost had been increased, then there would be a requirement to look further for justification of why the increase in cost was warranted. If the contractor is able to increase the MTBF at a minor cost, then it should be pursued. Although some of the areas investigated did not show signs of significant improvement, there were no areas of the analysis that were any worse off. This still does not change the fact that the existing box is inadequate; therefore, an investigation into the other possible alternatives is necessary.

New Box Design. Just as in the existing box design, a two-step increase of 10 percent, for a total of 20 percent, was accomplished on parts 88XX0 and 88XY0 for the new box. The procedure accomplished for this event is almost identical to the one used previously in the existing box scenario. One major difference was that the system being used in the what-if analysis (new box) was selected as the comparison file, <Alt M>. The other two files were selected as benchmarks, <Alt B>. In this analysis the existing box was selected as the first benchmark to aid in the visual comparisons.

The ability of the modified parts to meet the five R&M 2000 Goals is shown in Figure 22. Once again, the

mobility and manpower goals were not affected by the change in the MTBF. Just like before, the LCC change is not visible on the graph; however, the 20 percent change in the MTBF brought about a reduction of about \$170,000 over the total LCC of the system. Both combat capability and survivability were already at 100 percent; therefore, improvements were not possible. At first glance, there seems to be little reason to continue with a sensitivity analysis where there is 'no improvement' really possible.

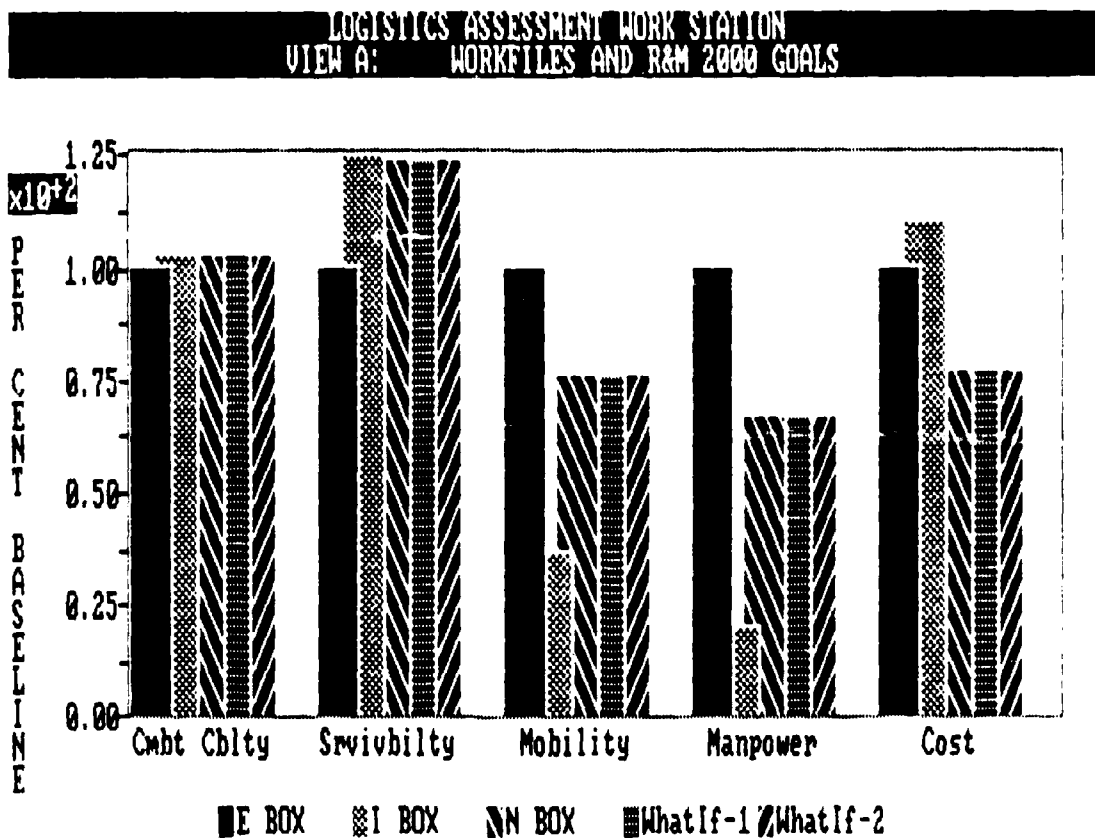


Figure 22. Workfiles and R&M 2000 Goals (View A)
New Box What-if Analysis.

Figure 23 depicts the increase of the MTBF affect on the expected number of sorties. As previously pointed out, the combat capability and survivability cannot hardly be improved upon; therefore, the 20 percent increase has no effect on the expected number of sorties.

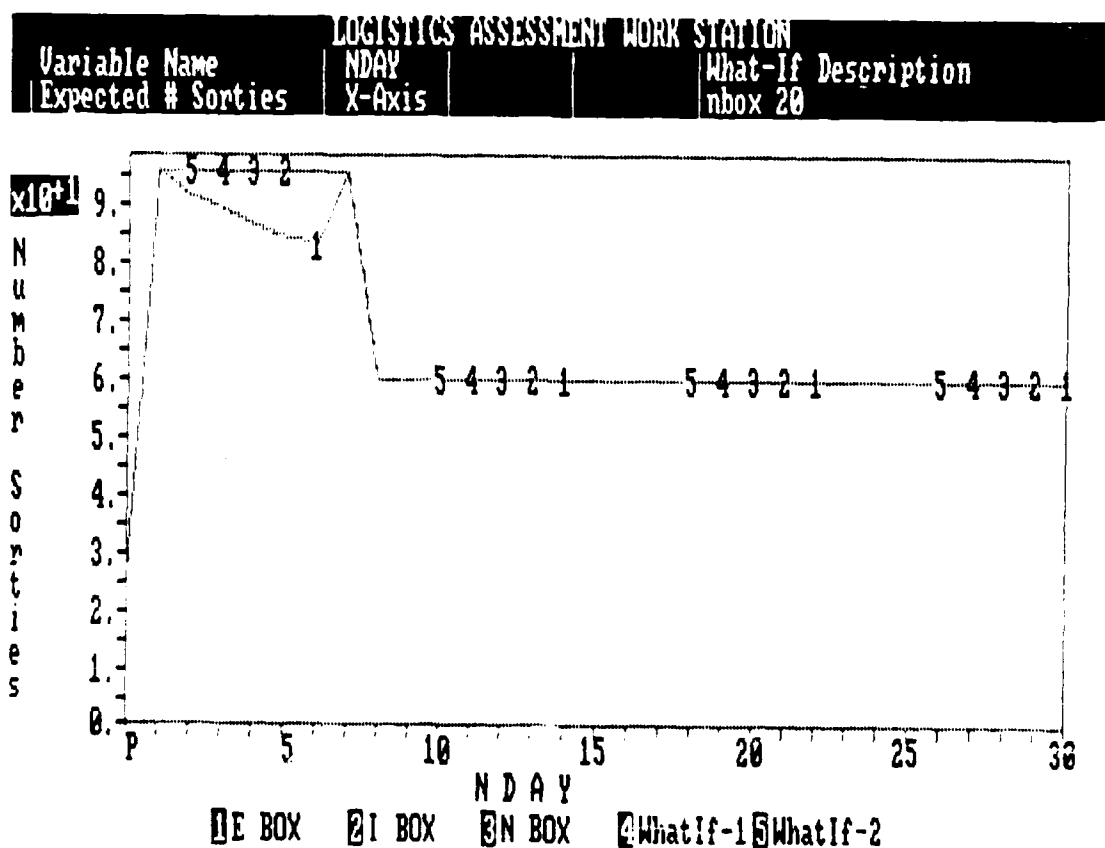


Figure 23. Expected Number of Sorties (View B)
New Box What-if Analysis.

The increase in the expected number of FMC aircraft is shown below in Figure 24. There is a slight difference in the ability of the new box to meet peace-time requirements. As seen before in the existing box, the difference equates to only portions of an aircraft. There was no identifiable differences in the conflict period either.

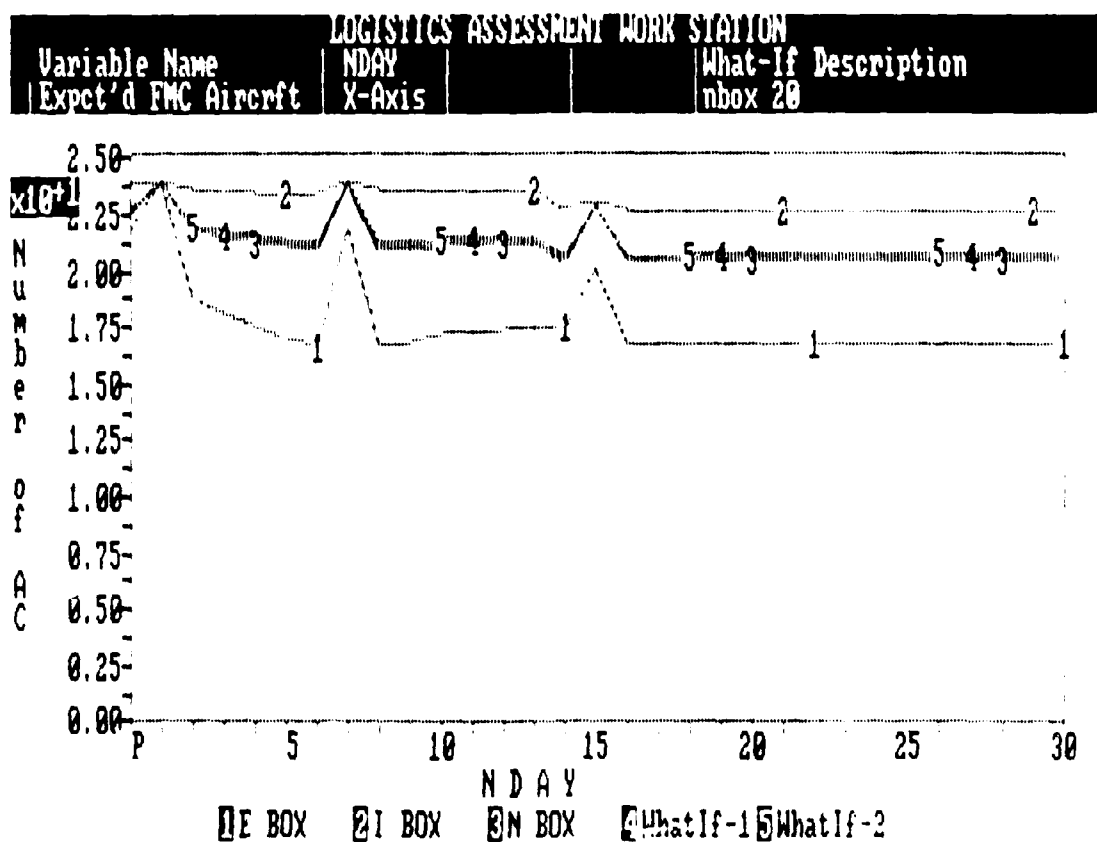


Figure 24. Expected FMC Aircraft (View B)
New Box What-if Analysis.

The increase in the MTBF had only a minor impact on the reduction of back-orders during conflict. A graph of the back-orders is below in Figure 25. As before, part 88XZ0 was not changed during the analysis. Part 88XX0 realized a reduction from 43 to 36 back-orders (17 percent less). The number of back-orders for part 88XY0 were also reduced from 52 to 43 back-orders (17 percent less). This decrease in the amount of back-orders still had no significant impact on the combat capability, FMC rates, or survivability of the system.

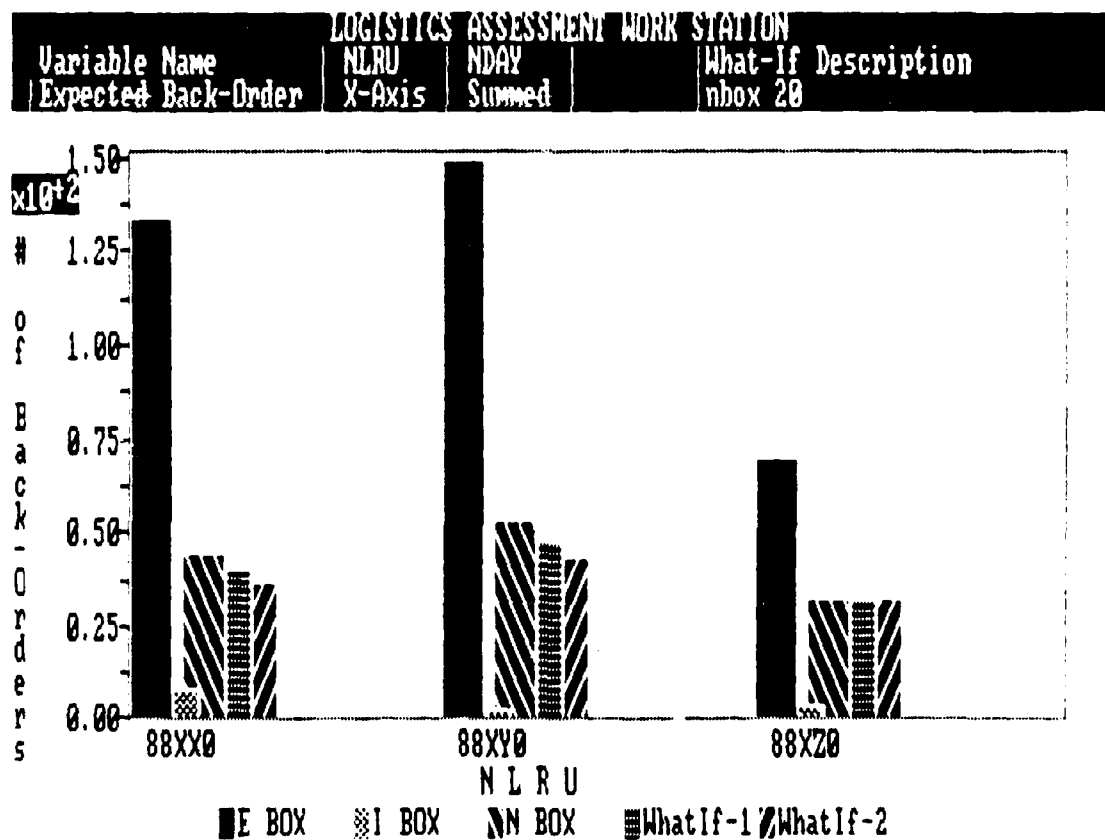


Figure 25. Summed Expected Back-Orders (View B)
New Box What-if Analysis.

The number of sorties without maintenance for the new box is conceivable, but still far from the number of sorties possible with the improved version of the box. Figure 26 portrays the impact that the 20 percent increase in MTBF had on the new box. The result was an increased sortie capability from 49 to 56 sorties without any maintenance. It is logical to assume that this increase would have an impact on survivability. The reason that it does not, is that it still has the capability to meet the tasking of the simulated tactical environment.

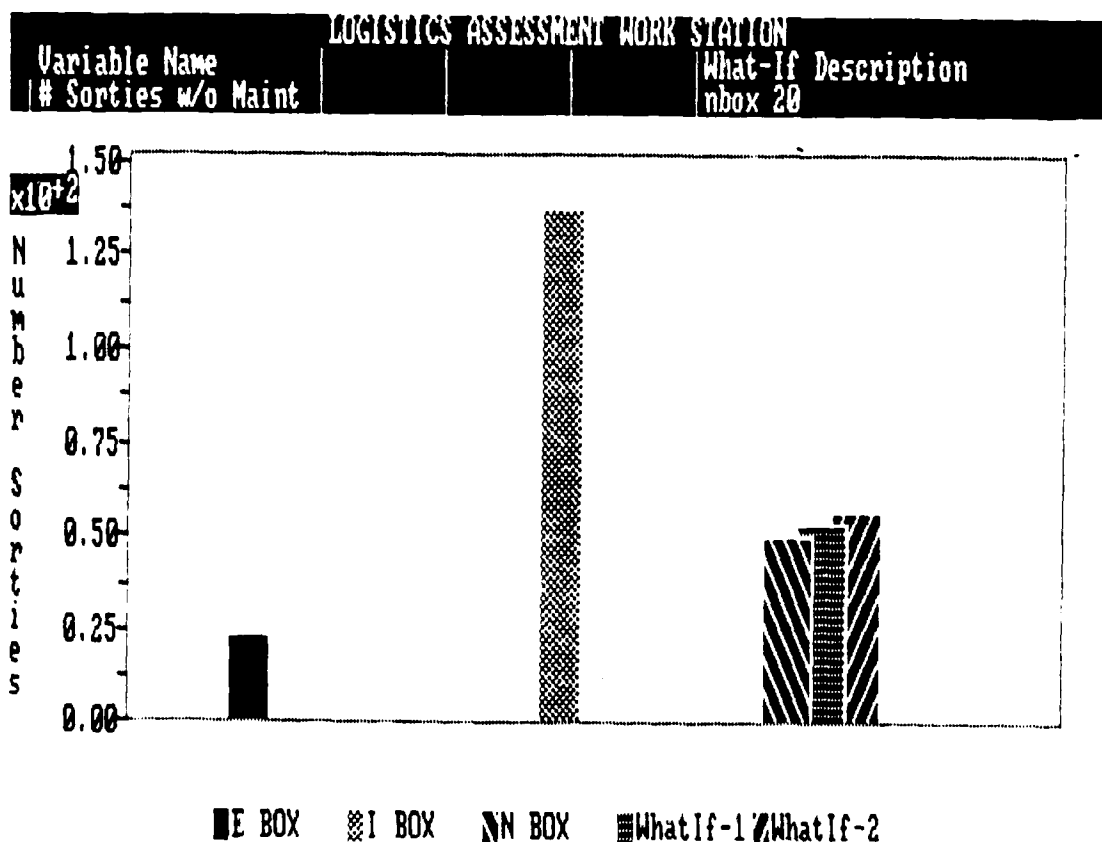


Figure 26. Number of Sorties Without Maintenance (View B)
New Box What-if Analysis.

The average failure rate of the system should show significant improvement when the MTBF is increased. As pointed out earlier, this depends on several things. Remember that 20 percent of a small amount is typically a negligible amount. The initial failure rate of the new box was predicted to be 15 failures per every 1000 hours of operation. The 20 percent increase in MTBF of the two parts made the difference of only one less failure, 14 failures, per every 1000 hours.

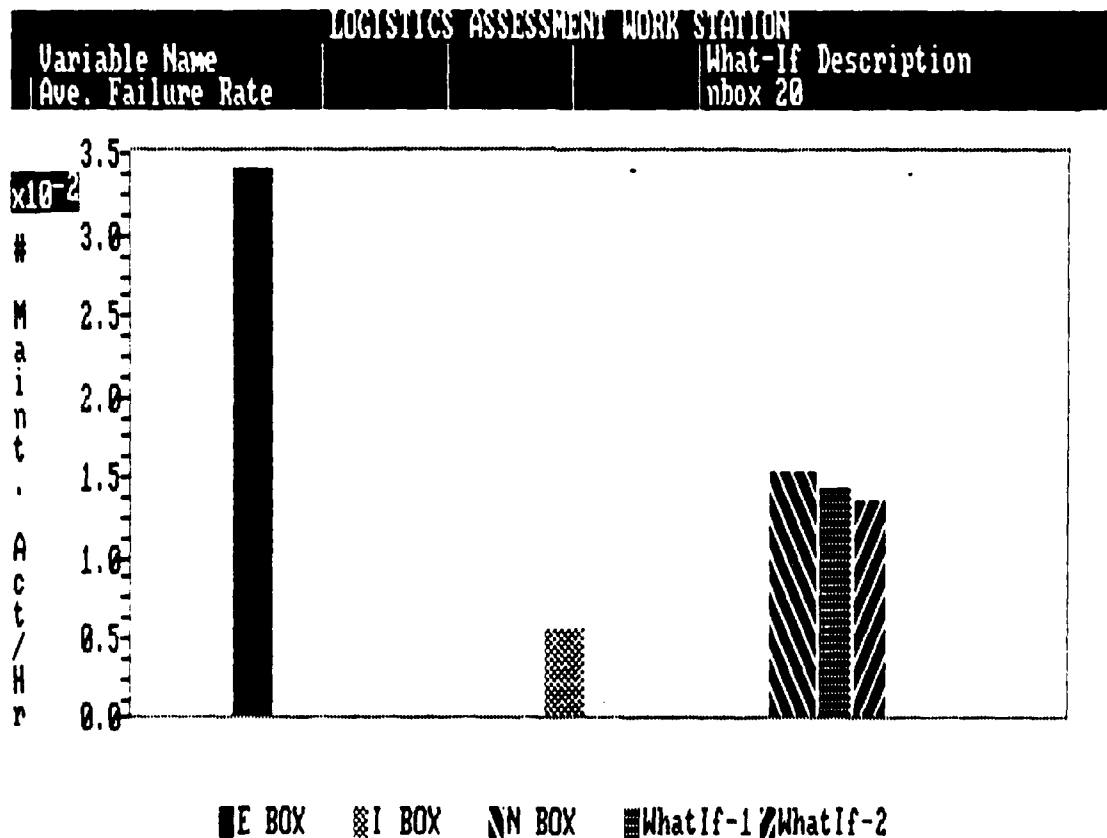


Figure 27. Average Failure Rate (View B)
New Box What-if Analysis.

Figure 28 below portrays that the 20 percent increase in MTBF does not have any significant affect on the predicted number of sorties without intermediate level maintenance. The greatest number of sorties difference was about a half a sortie during five days of the first week of the war.

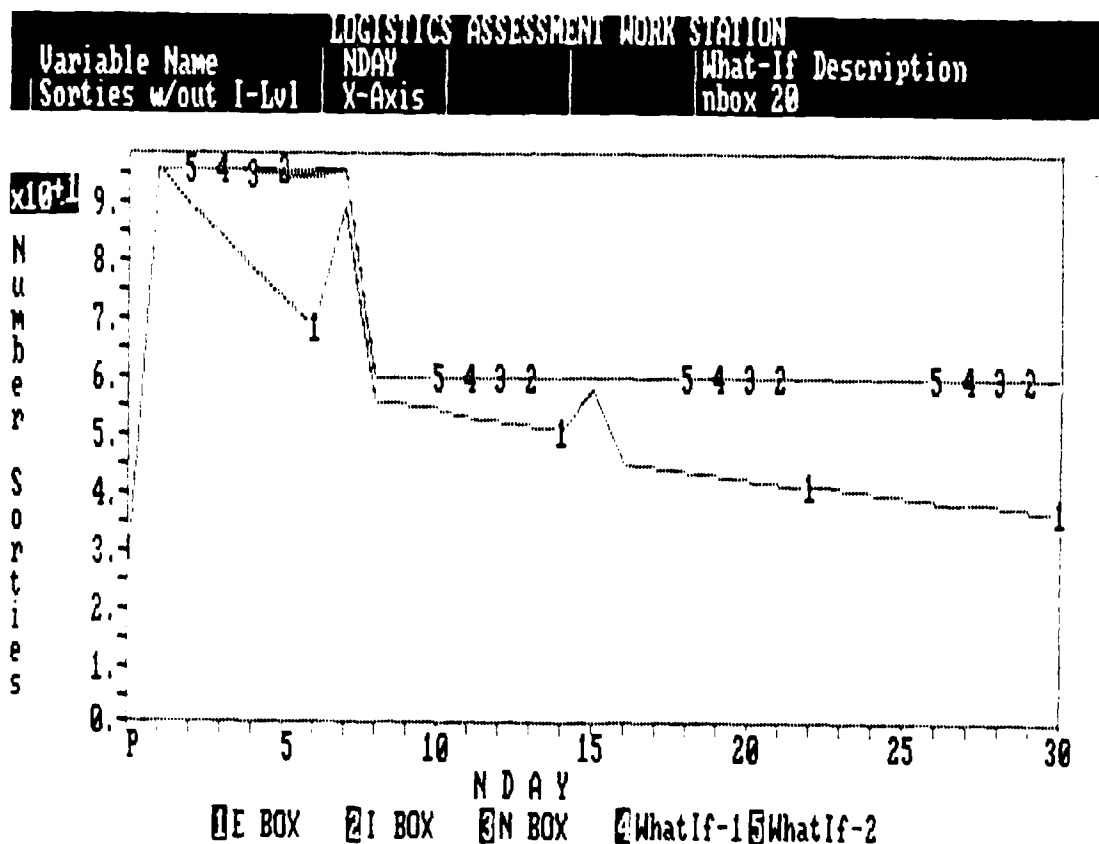


Figure 28. Sorties Without I-Level Maintenance (View B)
New Box What-if Analysis.

The most significant part of the sensitivity analysis of the new box was the fact that \$170,000 could be saved in the total LCC. The benefits which were

derived from the implementation of the increased MTBF were negligible. Each of the minor changes noted are important when they are all added together. None of the changes are significant by themselves to warrant the effort of modifying contracts and tracking the changes. The items just mentioned could conceivably exhaust any possible savings. In light of the possible benefits displayed in Figures 22 through 28, I would accept the contractor proposal to spend the extra \$20,000 per part for a increased performance of the part.

Improved Box Design. Once more, a two-step increase of 10 percent each was used in the accomplishment of the sensitivity analysis. In this instance, parts 88XX0 and 88XZ0 were used for analysis. The contractor had done such a wonderful job of designing the new part 88XY0 that it was no longer a problem area. Unfortunately, the two parts chosen were still a greater problem than the one remaining part; even with a 20 percent increase in MTBF of the two selected parts. The same basic procedure, as described in the flow diagram, was used for this analysis. The major differences involved the selection of the existing box for the first benchmark, and the selection of the improved box for the comparison, <Alt M>.

The ability of the modified parts to meet the five R&M 2000 Goals is shown in Figure 29. Since the existing box was selected to be the benchmark, all of the

data in Figure 29 refers to the existing box data for a baseline for comparison. It may first appear confusing to see survivability and combat capability with numbers greater than 100 percent.

As predicted earlier, the mobility and manpower goals did not change. Although not visible on the graph, the 20 percent change in MTBF brought about a total reduction of \$30,000 over the total LCC of the system.

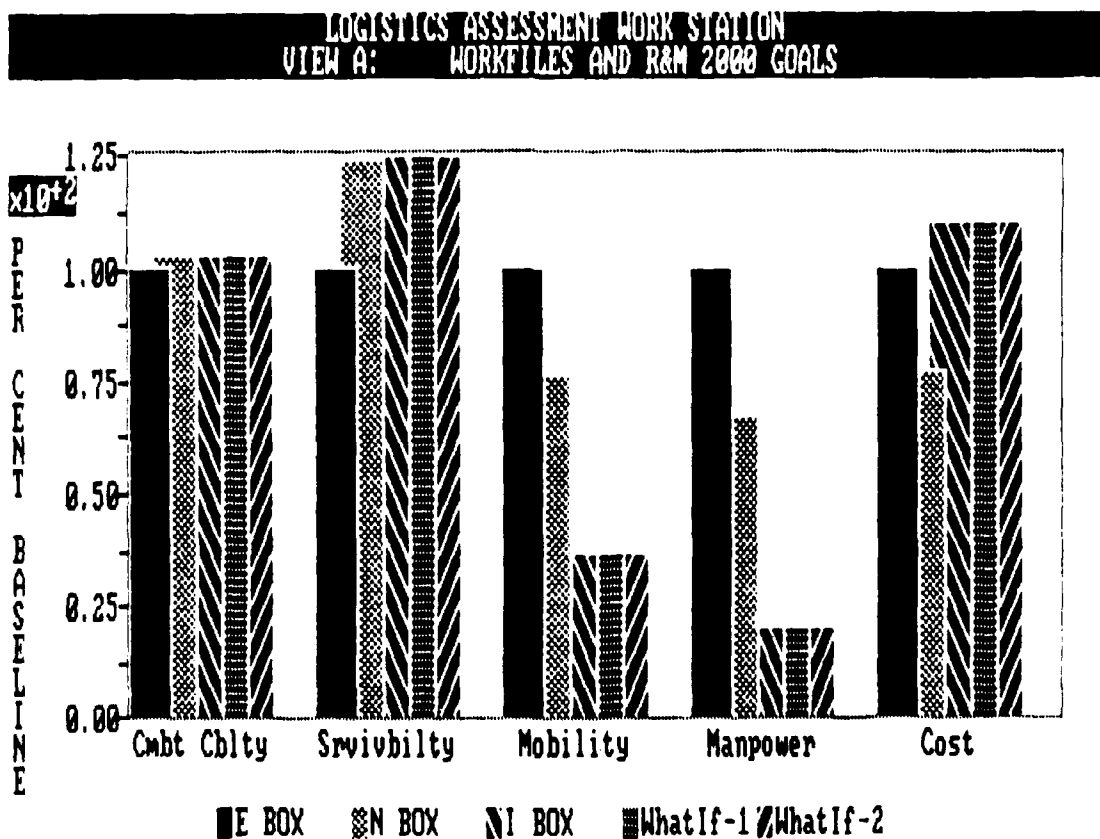


Figure 29. Workfiles and R&M 2000 Goals (View A)
Improved Box What-if Analysis.

Figure 30 depicts the increase of the MTBF affect on the expected number of sorties. There is no dramatic change noted in the graph. This is commensurate with the graph shown previously, Figure 29. Review of the data indicates that the expected number of sorties does not change at all. A change in this data could affect the combat capability and the survivability of the system.

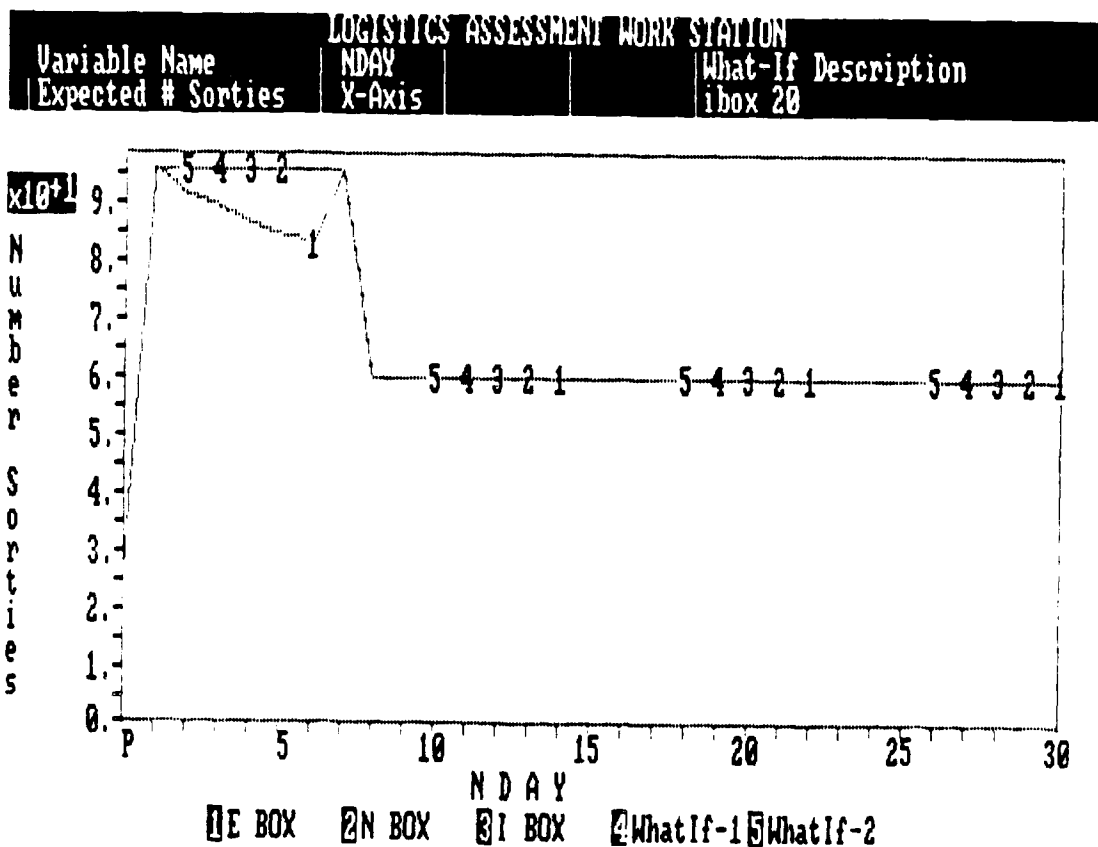


Figure 30. Expected Number of Sorties (View B)
Improved Box What-if Analysis.

The increase in the expected number of FMC aircraft is shown below in Figure 31. There is a slight difference in the ability of the improved box to meet peace-time requirements; however, the difference is truly negligible, availability of 23.87 with the increase, as opposed to a 23.84 without the increase. The same basic discovery was found in the 30 day conflict. Only minor differences were noted; 23.59 as opposed to 23.64 on day number six.

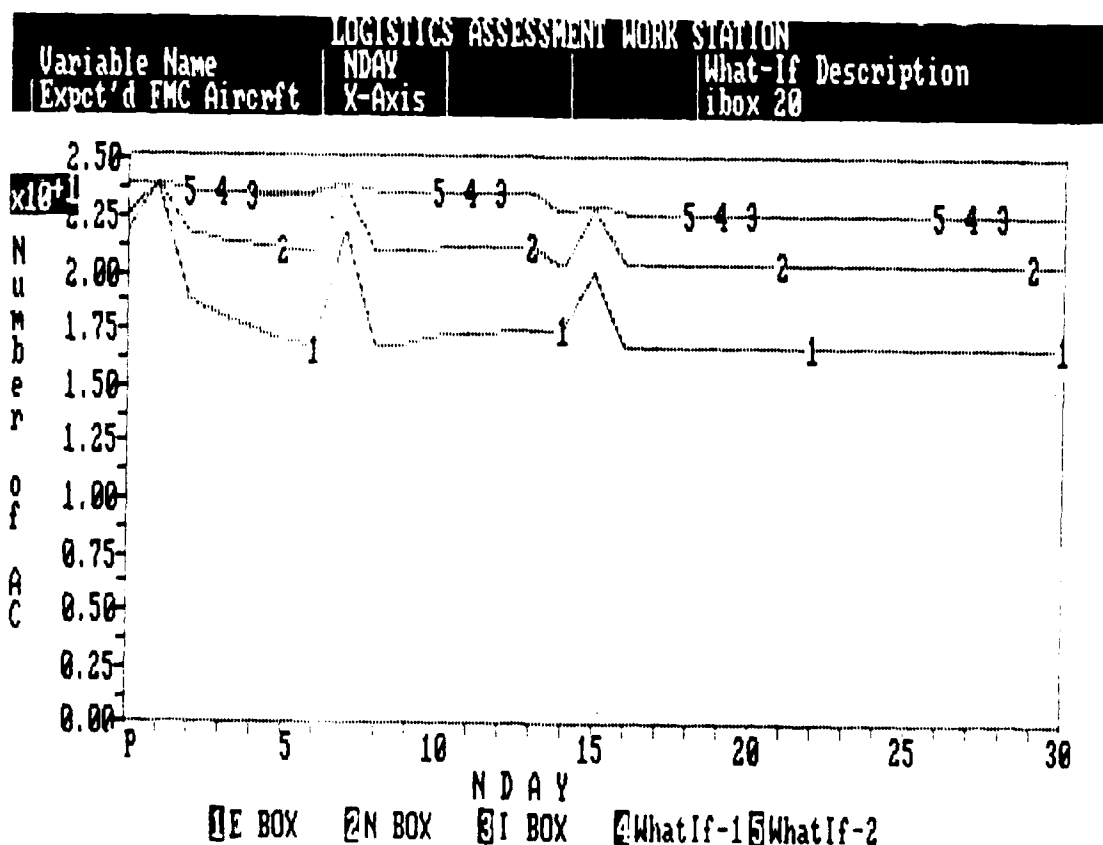


Figure 31. Expected FMC Aircraft (View B)
Improved Box What-if Analysis.

The increase in the MTBF did reflect an impact on the reduction of back-orders during a conflict. A graphic display of back-orders is provided below in Figure 32. Of course, part 88XY0 was not changed because it did not undergo the analysis. Part 88XX0 realized a reduction from 7.2 to 5.9 back-orders, while part 88XZ0 was reduced from 2.5 to 2.1 back-orders. This increase in the MTBF did nothing to improve the already outstanding performance of the improved box combat capability, FMC rates, and survivability.

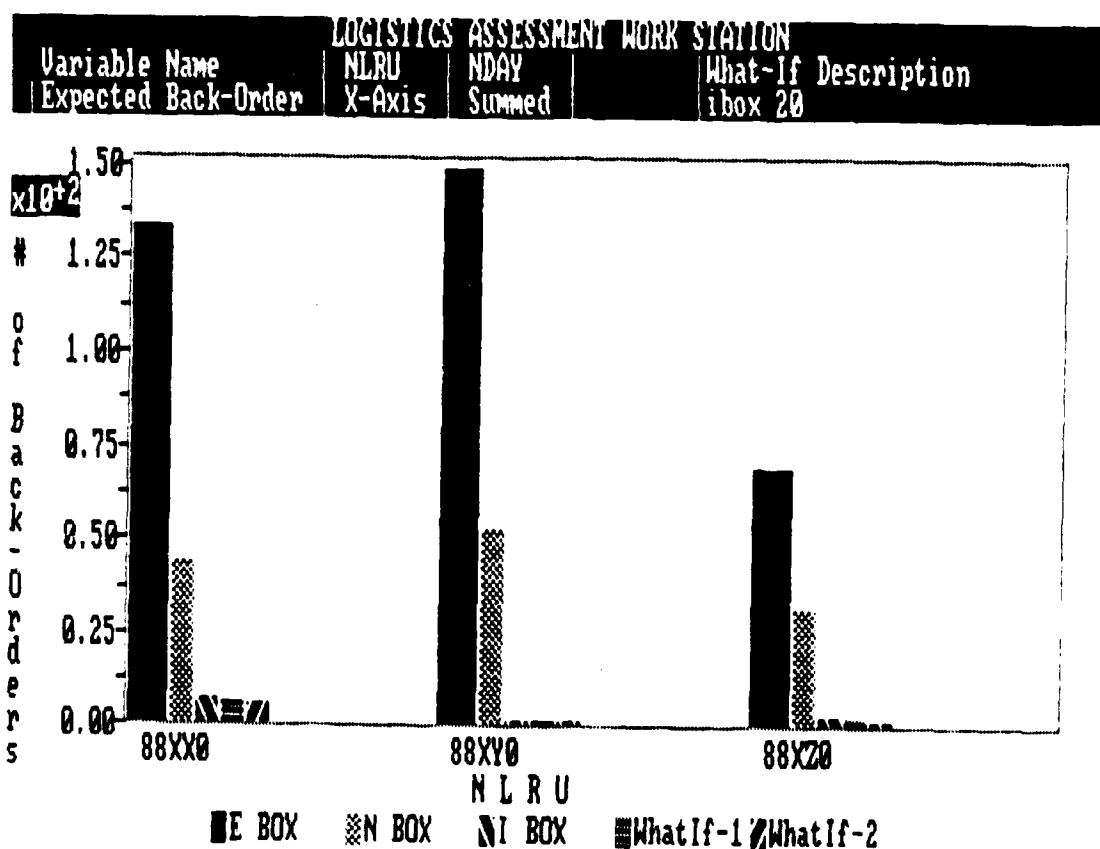


Figure 32. Summed Expected Back-Orders (View B)
Improved Box What-if Analysis.

The number of sorties without maintenance for the improved box showed some improvement over the number of sorties otherwise available before the 20 percent increase. Figure 33 below portrays the impact that the increase in MTBF had on the system. The result was a jump from 136 to 154 sorties for the improved box without any maintenance. This is by far the most striking benefit of the increased MTBF of the improved box.

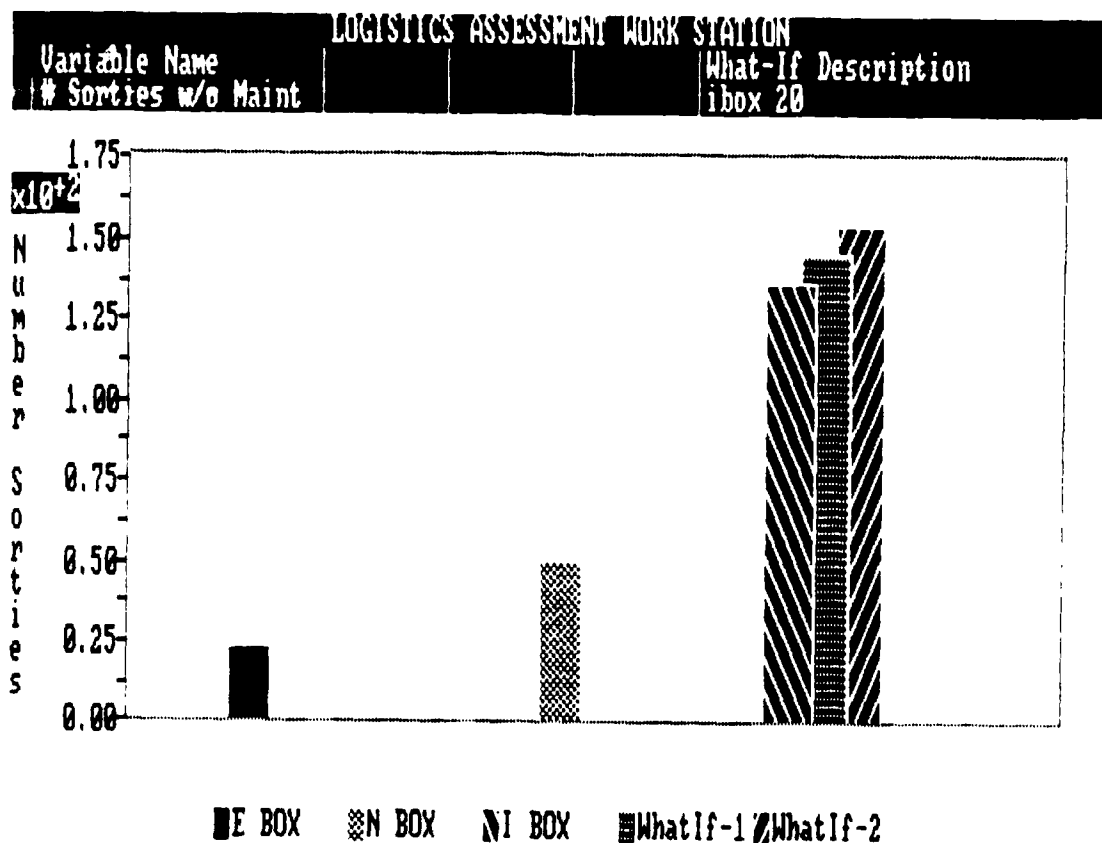


Figure 33. Number of Sorties Without Maintenance (View B) Improved Box What-if Analysis.

The average failure rate of the system should show significant improvement when the MTBF is increased. Yet, because of the extremely low failure rate of the improved box, the number of predicted failures per every 1000 hours of operation went from 6 to 5 for every 1000 hours.

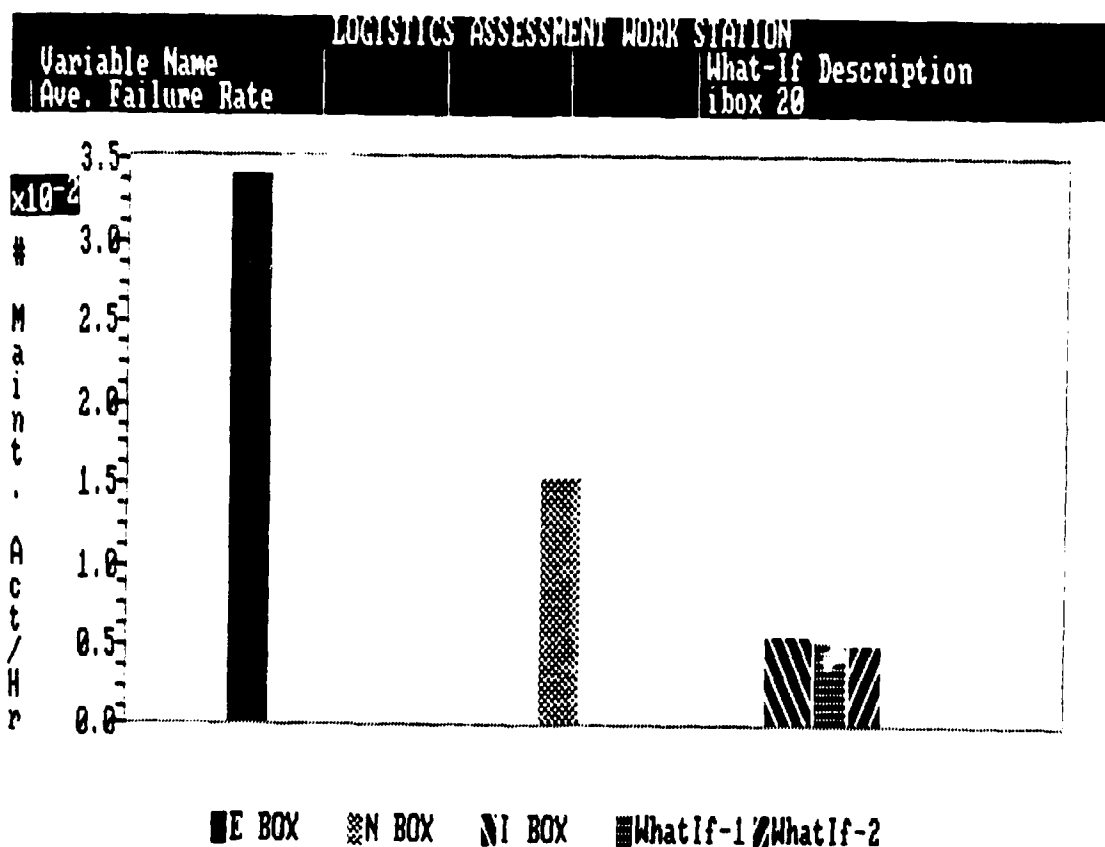


Figure 34. Average Failure Rate (View B)
Improved Box What-if Analysis.

It is apparent in the graph below that the 20 percent increase in MTBF does not have any affect on the predicted number of sorties without intermediate level maintenance when the item has such a low failure rate and when the item is used in the intended operational environment depicted here. There were no noted differences in the number of sorties for this particular sensitivity analysis.

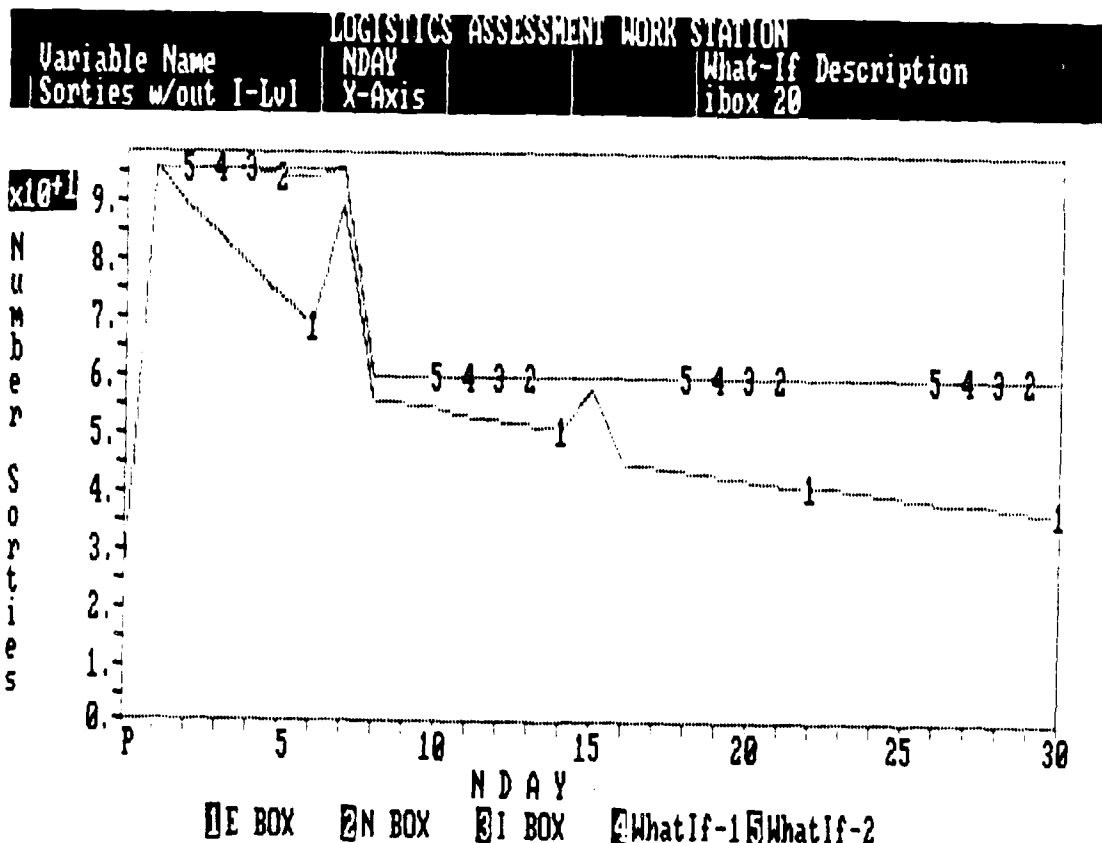


Figure 35. Sorties Without I-Level Maintenance (View B)
Improved Box What-if Analysis.

Considering all of the data presented in the sensitivity analysis of the improved box, the LCC was the only item identifiably reduced. The next most significant event was the increase in the number of sorties without maintenance; however, moving upwards from 136 is not identifiably different. Because of the costs associated with contract amendments and change proposals, the acceptance of this contractor proposal should only be considered as a test case to see if the objectives can really be met.

Summary

This chapter provided copious amounts of data and associated figures to describe the findings of a LAWS analysis of three fictitious black box designs. Additionally, data derived from three separate LAWS sensitivity analyses were presented. Chapter VI of this paper summarizes the findings of the analyses and presents conclusions and recommendations about the LAWS software and the programs accomplished.

VI. Conclusions and Recommendations

The purpose of this paper was to develop a training package to allow future acquisition logistics students at the Air Force Institute of Technology to obtain some hands-on experience in the use of the LAMP/LAWS methodology.

Overview

This chapter provides a brief summary of the problem and the results of the LAWS assessment. Recommendations for future LAWS applications are also provided.

Problem Development

LAWS software and manuals were obtained from the DRC corporation and a scenario and associated data files were developed for the procurement problem scenario. A simulated procurement problem was developed where the SPO, after obtaining failure rate data through the LOGTIES program, dispatched RFPs to eliminate the problem parts. Contractors responded to the RFPs with three proposed designs.

Three fictitious black box designs and associated non-performance characteristics were assembled along with bogus support sets. The assessments involved use of the boxes in the same simulated tactical operational scenario.

The three boxes were labeled as existing, new and improved.

The existing box was a design that was 'supposedly' currently in the field and was creating logistical problems. The new design was a 'beefed-up' version of the existing box. The areas that had been identified as weak had been reinforced. The improved design was a significant improvement with a modular design and built-in-test feature to allow for ease of repair, rapid problem identification, and elimination of the intermediate level of maintenance.

A logistics assessment and finally a sensitivity analysis were performed on the three designs.

Conclusions

Conclusions to this paper are divided up into three sections; one to address the normal utility of the LAWS assessment, second to address the additional capability of the LAWS to accomplish a sensitivity analysis, and third to address items specific to the software.

Logistics Assessment. As might have been expected, the inadequacies of the existing design were extremely evident. However, the new and the improved designs did not have a clear winner because of the trade-offs encountered. The 'best' selection depends on which of the five R&M 2000 Goals deserve the most emphasis.

Both the new and the improved designs displayed a 100 percent combat capability and survivability. The trade-offs encountered were in the areas of mobility, manpower, and life-cycle costs.

Because of the increased reliability of the new box, it had a lower life-cycle cost than the even the existing box; \$1.842 billion as opposed to \$2.4 billion. The improved box had a significantly higher price tag of \$2.644 billion because of the built-in-test and the modular design.

Due to the reduced level of maintenance and the elimination of the requirement for the intermediate level of maintenance, the improved box showed a significant reduction in the areas of mobility and manpower. Figures for the number of C-141Bs required to transport WRSK kits, personnel, support equipment, and facilities for the two designs were 9.47 and 4.51 for the new and improved designs, respectively. The number of manpower authorizations required per aircraft for maintenance of the system added up to 0.42 and 0.13 for the new and improved designs.

The benefits of the improved box design are significant and would sway many folks to opt for this alternative; however, the higher life-cycle cost of \$558 million is a bitter pill to swallow.

This is truly a management decision that calls for some real trade-offs. The major question is one of whether or not the decreased mobility and manpower requirements are worth half a billion dollars. The benefits derived from the new design are viewed by many to be worth the extra cost.

Sensitivity Analysis. The LAWS software possesses the capability to examine trade-offs through sensitivity analysis to determine how the change in one area may have an impact in other areas. The scenario of the problem presents the criterion that the MTBF of any two of the parts for each design may be increased up to 20 percent for an additional cost per part of \$20,000.

Since the criterion dealt with the MTBF and LCC, the impact of the analyses on mobility and manpower was non-existent. Therefore, the analysis comes down to a trade-off between the increase in combat capability and survivability, at the expense of changes in the total LCC.

Prior to the analysis, the improved box showed a combat capability and survivability of 100 percent. Therefore, the criterion for this situation becomes one of the impact on LCC. The sensitivity analysis disclosed that the LCC could be decreased by \$30,000 over the 20-year life of the system. Considering the time, effort, and money involved in contract negotiations, coupled with

the fact that contractors 'projected' prices are historically low, the savings will probably never materialize. Furthermore, the actual cash value of the projected savings is much less in 'then-year' dollars. Most decision makers would probably require further information in order to make this procurement decision; the numbers are simply too close.

Basically, the same situation for the improved box was again experienced with the sensitivity analysis of the new box. It too had a 100 percent combat capability and survivability prior to the analysis. The LCC cost savings were projected to be \$170,000 if the increased MTBF change were incorporated. The larger cash savings make the cost of the improvement worthy, even if the other goals were not 'significantly' enhanced. It should also be noted that there were minor improvements in several areas such as an increase from 49 to 56 in the expected numbers of sorties without maintenance. These numbers still did not add to the already 'substantial' capabilities of the design.

The most significant improvement was seen in the sensitivity analysis of the existing box. The combat capability was increased from 98 to 99 percent, the survivability was increased from 81 to 90 percent, and the LCC was reduced by \$70,000. The cost is not as

substantial as might have been expected, but the improvements in the other areas, especially survivability, make this change to the MTBF a worthy investment; providing that it is selected to be the procurement option.

Software. Overall, the LAMP/LAWS environment was user friendly and easy to learn. Easy to understand user options and definitions of variables were available at the touch of a key. Some minor problems were encountered such as the inability to accomplish assessments with more than one uniform value listed in the cost to process computer code. The computer wanted to do one of two things. Either it changed the costs to process codes to a standard value, or else it did the analysis and came up with a negative life-cycle cost. DRC has been made aware of the situation and they should correct the problem in the next version of the software. Other than this, the use of the LAWS provided consistent results indicating that the software is reliable.

Recommendations

The LAMP/LAWS methodology scenario presented in this paper should be used to further the education and training of PCE and graduate students of AFIT. When used in an academic environment, students should be encouraged to browse the files and to make changes to the data to see

how the ten ILS elements impact and are interrelated with the five R&M Goals. Changes made by students to the data can be rectified by inserting the provided diskette and re-loading the data files as done at the start of the exercise.

Because of the analyses and scenario presented in this paper, it lends itself well to be used as a tool for acquisition managers outside of the academic environment.

With the increased emphasis on the use of computer aided tools in the design and manufacture arena, more tools of this type are needed to insure that proper instruction and training are provided to the users.

The what-if analysis of the LAWS software lends itself well to gaining insights to optimum points in the ILS elements and R&M 2000 Goals. Further study should include an attempt to find optimal points and then to develop a complete maintenance concept for an existing or developmental procurement item.

Appendix A: Read.me Text File of
the Problem Statement

You are the Deputy Program Manager for Logistics of a section of the F-16 System Program Office (SPO). Ever since the planes' conception, the same black box has been in use. According to information provided by the AFLC Logistics Operations Center (LOC) under the LOGTIES program, it has become evident that the box is failing too frequently and resulting in an exorbitant amount of manhours to repair. The time has come to procure another black box.

There were three favorable responses to the Request for Proposal (RFP) dispatched to correct the deficiency. The first response was to replace the existing black box with a duplicate item. The major advantage to this approach is that there are no associated costs for the Research and Development (R&D). The cost to replace the each of the boxes are shown below in Table XXXVIII.

The second response to the RFP was a heavy duty model of the existing box; hereafter referred to as the 'new box'. This box provides increased reliability and maintainability with a price tag that is directly proportionate. The R&D cost of the new box is estimated at \$39,000.00 per flying squadron.

The third response to the RFP is an improved version of the box which incorporates a modular design, is much more reliable and is significantly easier to maintain. Also, the 'improved box' has a modular design and a built in test feature that eliminates the need for the intermediate level of maintenance. The cost associated with the R&D is \$470,000.00 per squadron.

Your job, should you decide to accept it, is to analyze the LAWS workfiles to assess which of the three design alternatives provides the best choice for procurement in regards to fulfillment of the five R&M 2000 goals. Now, just when you thought that it was safe to make a decision, the contractor for the items you didn't select comes up to you and states that the MTBF of two of the system parts can be increased through Engineering Change Proposals (ECPs) by as much as 20 percent at a cost of \$1,000.00 per percentage point increase (you get to pick which parts). To make for an easy sensitivity analysis, use 2 steps multiplied by 1.1 and add \$10,000 (10000) per step.

Table XXXVIII. Design Impacts on ILS Elements.

ILS Element	Existing	New	Improved
Design Interface (MTBF)	37	78	184
Maintenance Planning (Maint hours/fly hour)	1.08	0.42	0.19
Supply Support / Spares (Thousands of Dollars)	259.6	360.9	486.5
Support Equipment (Millions of Dollars)	78.36	60.38	3.04
Packaging/Handling/Trans. (Flightline/Shop)	1.83	1.83	00
(Shop/Depot/Shop)	14.6	11.0	7.33
Technical Data Cost (Thousands of Dollars)	264.6	441.0	529.2
Facilities Cost (Millions of Dollars)	3.08	2.31	0.22
Manpower (Mean Hours to Maintain)	44.61	41.91	24.5
Training Cost (Thousands of Dollars)	141.8	94.6	28.4
Computer Resources Cost (Thousands of Dollars)	16.87	21.75	29.25

After careful consideration, you are now almost ready to throw in the towel when your apprentice recommends that you apply LAWS technology to this mind-boggling scenario. You wholeheartedly agree as you place the pistol slowly back into its holster. The dust is carefully removed from the LAWS Workfile disk and you jump into action.

Insure that you are on a PC that has a LAWS directory. To load the required workfiles into the LAWS directory, type the following information at the "A" prompt: A:> Load <CR>. "Load" will replace new data files over existing data files already in the LAWS directory.

In order to obtain a hard copy of the graphs provided during data analysis, follow the instructions below:

(1) Press <Alt P> one time when the desired graph you wish to print is on the screen. You should see/hear that the hard drive is working to save the picture.

(2) At the end of the working session, use the <Esc> key to get back to the LAWS root directory and then follow the commands listed below:

```
C:\LAWS> CD\  
C:>      Graphics  
C:>      CD\LAWS  
C:\LAWS> Picture  
C:\LAWS> laws.pic
```

If you want a copy of this text, exit this page and type the following information at the 'A' prompt:
A:> Print Read.me <Carriage Return> (<CR>).

Notes:

(1) LAWS analysis requires that 640K be available. If not, the number of positions for the benchmark, <Alt B>, at the 'Data Analysis' level will be reduced from six. If this happens, REBOOT (<Ctrl-Alt-Del>). this action will eliminate any information eating up your available 640K RAM. The data files you already installed will not have to be reloaded. Simply go back to the root directory C:\> and type 'CD\ LAWS <CR>, LAWS <CR>'.

(2) After accomplishing a WHAT-IF analysis, exit the program without saving the analysis unless you really think that it is necessary. Should you want to accomplish more than one analysis, escape all the way out of LAWS and reload the program before you start the second analysis. Some minor problems have been encountered in the attempt to do more than one what-if at a time. DRC is aware of the problem and a solution is in work; to be included in the next version.

(3) You cannot selectively save what-if analysis; therefore, escape to the 'data development' stage and go <Workfiles>, <List/Delete>, and <Alt X> to remove unwanted files. Should you delete the wrong files, you will have to reload all data and start again.

(4) When accomplishing the data analysis and saving pictures with the <Alt P> command, all screens are saved into the default file called "LAWS.PIC". If a second session of analysis is begun, the data pictures in the initial LAWS.PIC will be lost/overwritten. To avoid this, rename the LAWS.PIC file to another name such as EBOX.PIC or NBOX.PIC. Example:

C:\LAWS> Rename laws.pic nbox.pic <CR>.

The next time that you attempt to print pictures, go through the same steps as described above, except that the files (after C:\LAWS> Picture) selected should be whatever you selected for the name of the Pic file.

(5) Your next move should be one of the following:

- (a) A:\> Print Read.me <CR> [prints this file].
- (b) A:\> Load <CR> [puts files into LAWS and begins operation of the program].
- (c) A:\> <Ctrl - Alt - Del> [Quit/Reboot computer].

Appendix B: LAWS Analysis Flow Diagram

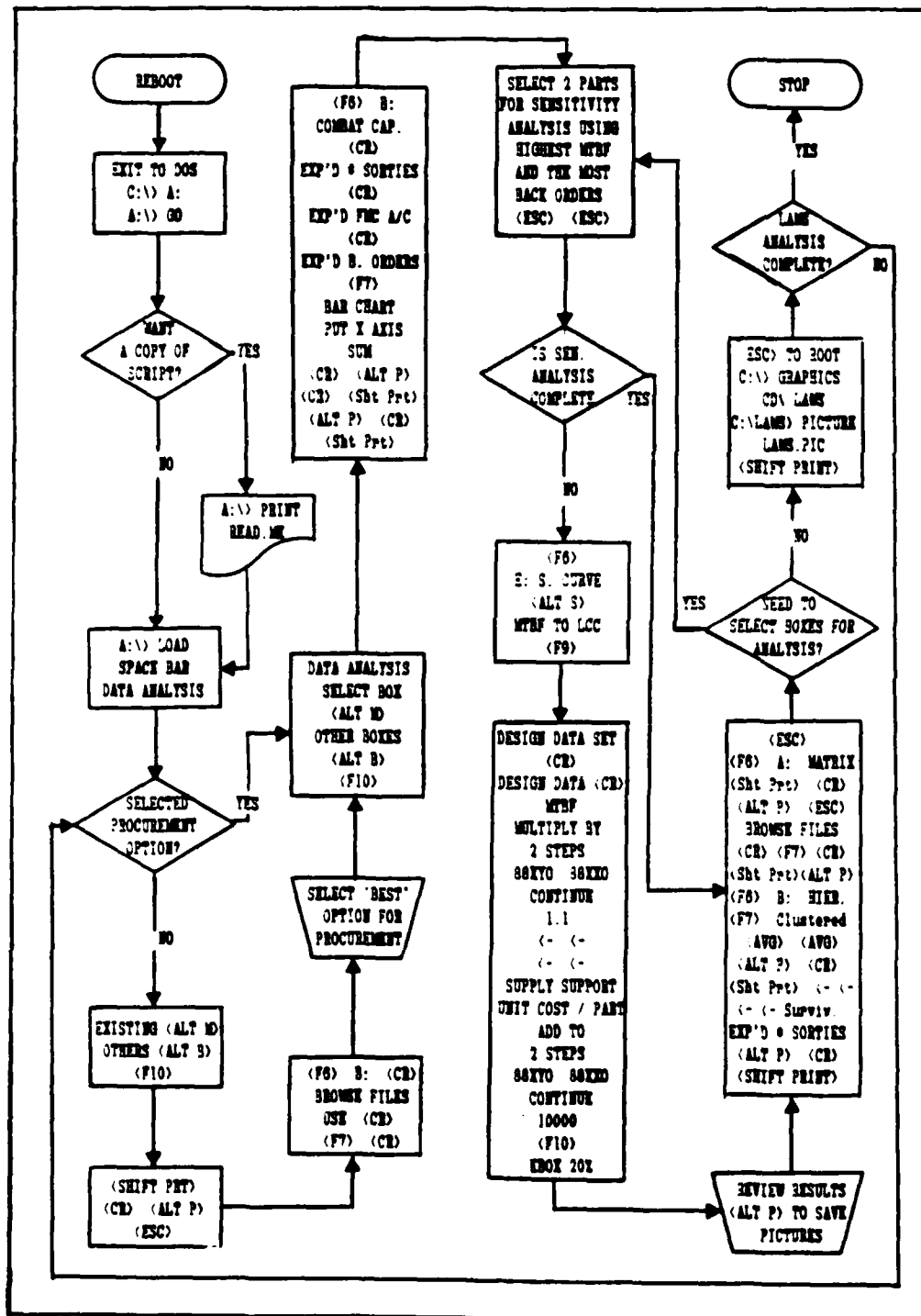


Figure 37. LAWS Analysis Flow Diagram.

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ADA201465

REPORT DOCUMENTATION PAGE

Form Approved
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1a. REPORT SECURITY CLASSIFICATION UNCLASSIFIED			1b. RESTRICTIVE MARKINGS		
2a. SECURITY CLASSIFICATION AUTHORITY			3. DISTRIBUTION / AVAILABILITY OF REPORT Approved for Public Release; distribution unlimited.		
2b. DECLASSIFICATION / DOWNGRADING SCHEDULE			5. MONITORING ORGANIZATION REPORT NUMBER(S)		
4. PERFORMING ORGANIZATION REPORT NUMBER(S) AFIT/GLM/LSM/88S-43			7a. NAME OF MONITORING ORGANIZATION		
6a. NAME OF PERFORMING ORGANIZATION School of Systems and Logistics		6b. OFFICE SYMBOL (if applicable) AFIT/LSM	7b. ADDRESS (City, State, and ZIP Code)		
6c. ADDRESS (City, State, and ZIP Code) Air Force Institute of Technology (AU) Wright-Patterson AFB, OH 45433-6583			9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER		
8a. NAME OF FUNDING / SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (if applicable)	10. SOURCE OF FUNDING NUMBERS		
8c. ADDRESS (City, State, and ZIP Code)			PROGRAM ELEMENT NO.	PROJECT NO.	TASK NO.
			WORK UNIT ACCESSION NO.		
11. TITLE (Include Security Classification) USING THE LOGISTICS ASSESSMENT METHODOLOGY PROTOTYPE MODEL FOR EDUCATION IN ACQUISITION LOGISTICS					
12. PERSONAL AUTHOR(S) Dennis N. Malott, B.S., M.P.A., Capt, USAF					
13a. TYPE OF REPORT MS Thesis		13b. TIME COVERED FROM _____ TO _____		14. DATE OF REPORT (Year, Month, Day) 1988 September	
				15. PAGE COUNT 136	
16. SUPPLEMENTARY NOTATION					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Logistics Assessment Work Station Logistics Assessment Methodology Prototype Reliability and Maintainability		
12	05				
19. ABSTRACT (Continue on reverse if necessary and identify by block number)					
Thesis Advisor: Robert D. Materna, Lieutenant Colonel, USAF Assistant Professor Department of Logistics Management					
Approved for public release IAW AFR 190-1.					
WILLIAM A. MAUER 17 Oct 88 Associate Dean School of Systems and Logistics Air Force Institute of Technology (AU) Wright-Patterson AFB OH 45433					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input checked="" type="checkbox"/> UNCLASSIFIED/UNLIMITED <input type="checkbox"/> SAME AS RPT <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
22a. NAME OF RESPONSIBLE INDIVIDUAL Robert D. Materna, Lt Col, USAF			22b. TELEPHONE (Include Area Code) (513) 255-5023		22c. OFFICE SYMBOL AFIT/LSM

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18. Cont.

Computer Aided Instruction
Acquisition Logistics
Computer Aided Logistics Support
Integrated Logistics Support

19. Cont.

The current emphasis on reliability and maintainability has resulted in the development of several computer aided management tools. The Logistics Assessment Work Station was developed under the Logistics Assessment Methodology Prototype Program and is a computer aided tool for acquisition managers. The purpose of this study was to develop a training package to provide students in acquisition logistics the opportunity to use this methodology to assess the logistics supportability of new or existing equipment.

A 5.25 inch diskette and a flow chart of procedures are included to provide students the needed information to allow them to accomplish a sensitivity analysis of a black box assembly under procurement consideration. Step-by-step instructions demonstrate the ease of use and the power contained in the LAWS algorithms to allow the user to accomplish an in-depth supportability analysis.

Overall, the training package enhances the quality and depth of the acquisition logistics education by exposing the student to a real world management tool which, if used properly, can make their job both faster and easier. LAWS software is a promising tool for logistics supportability analysis of both existing and new equipment items.

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